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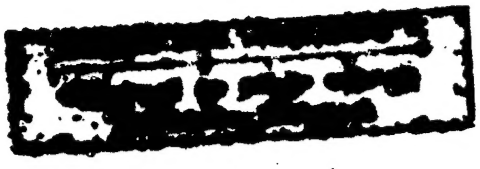
31 MARCH 1986

China Report

SCIENCE AND TECHNOLOGY



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CHINA REPORT
SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENT

ABSTRACTS

NATIONAL DEVELOPMENTS

BEIJING'S 1985 S&T ACHIEVEMENTS REPORTED

OW121113 Beijing XINHUA in English 0900 GMT 12 Feb 86

[Text] Beijing, 12 February (XINHUA)--Some 2,400 scientific and technical achievements were made last year in China's capital, according to today's BEIJING DAILY.

Three quarters of the achievements have been applied to production and have added 207 million yuan to production.

Seventy won national invention awards in 1985, the paper said.

Last year brought the city the greatest number of scientific and technical achievements and the best economic results, it noted.

Helping make research results commercially viable and serve the nation's economic development with technical know-how was China's first national technical trade fair held here last May. At it, the city displayed 3,200 achievements and ranked 2nd in business volume of China's 29 provinces, municipalities, and autonomous regions.

The city has also established 508 various economic undertakings to increase links between academic research and production.

Last year, 379 key technical transformation items were completed and put into production, creating 1.7 billion yuan a year in production value and bringing Beijing an increased 247 million yuan in profit.

/12232
CSO: 4010/2010

NATIONAL DEVELOPMENTS

HUNAN'S 10 MAJOR SCIENTIFIC ACHIEVEMENTS IN 1985

Changsha HUNAN RIBAO in Chinese 3 Jan 86 p 1

[Text] To encourage groups and individuals to make vital contributions to scientific and technical advance in the province, the provincial Science and Technology Commission has named Hunan's 10 major scientific and technical achievements for 1985 after consulting the departments concerned. The achievements are:

1. The Milky Way digital simulated computer and the Milky Way super microcomputer. The birthplace of China's first Milky Way -- the National Defense Science and Technology University -- has again researched and manufactured the Milky Way digital simulated computer and the Milky Way super microcomputer, which are of the highest international standard of the early 1980's. Their successful creation has tremendous economic and military significance.

2. Human high-resolution chromosome technology and its application. In a development that marks the entry of human cell genetics into a new stage, the Hunan Medical College has discovered a new technique to make and identify chromosome samples - human high-resolution chromosome technology. Its research in the manufacture, identification and application of high-resolution chromosome samples is a leader in the nation and on a par with the world.

3. Biliary passage. The No 1 Hospital attached to the Hunan Medical College has come up with a new kind of biliary passage surgery. Advanced, scientific and practical, this research is unprecedented in the country and has reached international standard.

4. Crucian carp crossbreeding research. A cooperative project between the Donghu Fish Farm in Xiangyin County, the Biology Department of the Hunan Normal University and the Hunan Marine Research Institute, crucian carp crossbreeding research produces outstanding economic results as well as being an academic breakthrough in basic theory. It is in the forefront of such research domestically and abroad.

5. Satellite remote-sensing applications research in the Lake Dongting area. Assigned by the State Science and Technology Commission, this project on "satellite remote-sensing in Lake Dongting" was brought to a successful end

through the joint effort of a dozen or so units, including the Hunan Economic and Geographic Research Institute and the training section of the National Remote Sensing Center. This piece of research is a pacesetter at home, with aspects of it reaching international level.

6. The regionalization of ramie varieties and its high-speed asexual reproduction. The Ramie Research Institute of the Hunan Academy of Agricultural Sciences and the Cash Crops Bureau of the provincial Agriculture Department successfully came up with a process to regionalize ramie varieties and produce it asexually fast. This achievement is both a domestic and international innovation.

7. Heavy-metal marine environment capacity research in Xiangjiang. Designated by the state as a key research project in the "Sixth 5-year Plan," heavy metal marine environment capacity research was undertaken and completed by the Hunan Environmental Protection Research Institute. It opens up new terrain in environmental science. Its achievements are the most advanced at home and, in some respects, in the world.

8. A method to grade the drillability of rock. Invented by the Changsha Mining Research Institute, this method makes possible on-site testing using irregular core samples and is convenient, fast, and inexpensive. It provides a feasible technique for determining the character of the rock on the spot, setting labor quotas and implementing scientific management. The research achievement has reached international level.

9. DC16-4 high-pressure direct-current circuit insulator. This insulator, the result of joint research between the Lujiang Electric Ceramics and Electric Appliance Co and the Electric Science Research Institute of the Ministry of Water Resources and Electric Power, filled a technical void in China. Its leading technical indicators show that it has achieved the level of comparative products abroad.

10. QT80A self-rising tower crane. The first self-rising crane made in China, the QT80A vastly enhances our ability to put up high-rise structures. The machine has an original design and, according to its leading technical indicators, is among the most advanced similar products in China.

12581
CSO: 4008/2061

NATIONAL DEVELOPMENTS

BEIJING PARTY SECRETARY ATTENDS FORUM OF RESEARCHERS

SK270147 Beijing BEIJING RIBAO in Chinese 7 Feb 86 p 1

[Text] Beijing Municipality has very favorable scientific and technological conditions. It is necessary to better display this condition through technical cooperation in order to promote the four modernizations in the capital. The above statement was given by Mayor Chen Xitong at a forum of responsible persons of some central scientific research units, colleges and universities in Beijing.

Comrades Li Ximing and Jiao Ruoyu showed their agreement with Chen Xitong's opinions by nodding frequently. Jiao Ruoyu said in particular that in reforming the scientific and technological system, we must break with the shackles and restrictions between departments and regions and carry out more lateral cooperations.

Last year our municipality scored great achievements in carrying out scientific and technological cooperation. The central scientific research units and colleges and universities in Beijing have exerted very great efforts and scored achievements in a great number of scientific and technological findings, playing a very good part in promoting technical progress among enterprises in the municipality. The responsible persons of 31 councils from the Beijing scientific and technological coordination center expressed their determination that they will actively carry out technical cooperation and exert efforts in the construction of the capital.

Comrades Lu Yucheng and Zhang Peng introduced the relevant situation of Beijing to the participants. The responsible person of the municipal Economic Commission gave an account of the numerous new tasks of the enterprises under the municipal Economic Commission.

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CSO: 4008/2068

NATIONAL DEVELOPMENTS

VALUE OF SCIENCE, DEVELOPMENT OF COMPUTERS DISCUSSED

Beijing KEXUE GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 4, Oct 85 pp 10-12, 6

[Article by Hong Jiawei [3163 0502 1218] of Beijing Computer Institute: "The Value of Science - and Development of Intelligent Computers"]

[Text] Science has application value, market value, and labor value. These are different values which are discussed in the following:

1. Application Value

In terms of application value, science and technology is productivity. Its effect on pushing mankind forward cannot be calculated in value. In other words, an estimate cannot be placed on science and technology.

The force to push human society forward is the productivity development and evolution of relations of production. The most effective, active, and determining factor, however, is the development of productivity. Productivity development is after all a result of progress in science and technology. Scientific and technological accomplishments reflect man's understanding and ability to harness nature. It shows the subjective activity of mankind. A review of our long history reveals that development in science and technology is the most profound reason for mankind to evolve from a primative society to the electronic world.

Of course, as a whole, science and technology is priceless. Not every technical achievement, however, is always priceless. Even major technical achievements which have a determining effect on the lives of mankind are priceless with respect to infinite time. Within any finite time period, the application value of any technical accomplishment is limited. Hence, we have to assign priorities.

Due to various complicated reasons, in the past some of our technology was not linked to economic construction. Therefore, the present economic reform requires many comrades to change their directions. Our experience shows that scientists with some theoretical background have the ability to undergo such a change to contribute significantly to economic construction. In addition, profound problems may be solved in practice.

In the following we will discuss a specific problem with strategic significance; i.e. the development of intelligent computers. Is an intelligent computer a priceless treasure? Is it worthwhile pursuing?

Computer has been around for 39 years. It is influencing the whole world and has penetrated into major territories in the human society. It plays the role of steam engine in the new technological revolution. Up till now, however, the development of four generations of computers has mainly relied on the improvement of components. There are fundamental defects in the system structure. Computers cannot process knowledge and perform logic deduction. They are also unable to conduct a dialogue with man in any natural language. Therefore, there must be a basic breakthrough in computer development. A new generation of computers--intelligent computers--will emerge.

The main special feature of such a new computer is that it will be able to process knowledge and perform logic deduction just as human beings. It can understand Chinese and work as a secretary. For instance, it can search technical literature, manage business and factory, take care of acres of land as an experienced farmer, educate children at home, do house chores and care for the elderly. By then our productivity will be significantly improved. Science and technology will move forward at a much faster pace. Human life will change drastically.

The intelligent computers, just as microcomputers today, will dominate the market. The Japanese believe that in the 1990's the world will be dependent upon intelligent machines just as we were on oil from the Middle East in the 1970's.

Surveillance systems, coding systems, intelligence systems, command systems, and controls systems in defense cannot survive without intelligent computers. Intelligent weapons will make most advanced weapons in the 1980's look like spring-wound toys.

To this end, leadership in the development of intelligent computer will result in a leading position in the economy, science, culture and defense. Intelligent computer is truly a priceless treasure.

2. Market Value

Although science is a priceless treasure, it is a pity that it does not have a market value (i.e. exchange value). At least up till now science is not a piece of merchandise and cannot be sold in the market. It simply does not have any market value. How much money can the laws of Newton or Einstein's theory of relativity be worth? None. Technology is different. It may become products or patent rights. For instance, computer softwares may become true commercial products after resolving certain problems.

The reason that science is not a piece of merchandise, at least as of yet, is because of the following major reasons. First, scientific results are usually some information which are summaries of laws governing the nature

and the development of a certain object. It is very difficult to achieve it for the first time, but very easy to propagate it. It is very hard to keep it a secret. For instance, everyone knows that the ratio of the circumference of a circle to its diameter is $\pi = 3.1415926$ and can make use of it. There is no way to patent it. It is also not possible to demand a royalty from people who use it. Second, the application value of scientific results usually lasts longer and the effect is more indirect. A scientific principle must rely on technology to transform into productivity. Hence, scientific accomplishments cannot bring immediate benefits to a individual or organization. Third, many technical accomplishments are based on the same scientific principle. Thus, scientific achievements, by nature, benefit the public. Individuals or organizations should not be asked to support it alone. The study of intelligent machines belongs to this category.

The sharp contradiction between the infinite application value and the lack of market value can only be resolved by government support of scientific efforts. For example, the development of intelligent computers can be listed as a focal item under which special policies apply. It is supported by a science foundation. If the government does not support it, under the circumstance that profit and service are stressed (which is necessary for the overall picture), this long-term research project may be bumped, resulting in unmeasurable loss. Because of the high rate of reeducation, there are very few people in China qualified to develop intelligent machines. Moreover, they are mostly lower paid young and middle-aged people whose bonuses will be affected because the development of intelligent computers cannot bring in immediate profits. If they give up this difficult task and perform ordinary technical work, their income will immediately increase by several folds. We have people with Ph. D. degrees giving up research to become businessmen. This situation makes the development of intelligent computers difficult to continue. In some places, the people involved in business get the largest cut. People engaged in development get the middle cut and the design people get the small cut. If we do not pay attention to this situation, medium- and long-term research projects will be strongly impacted.

Several years ago we went into the rural areas to help in harvesting. I used to sharpen sickles for everyone because I could do it fast and well. However, those who cut the most wheat received recognition, instead of me or the person who taught me how to sharpen the sickle. This demonstrates that work behind the scene is not recognized. Technical exchange is the same situation. Some comrades feel that several million yuans spent by the National Science Commission in technical exchanges are wasted. They believe that it is not very useful to hold so many academic meetings. They do not know that the exchange of scientific information and thinking is absolutely required. Its effect cannot be judged in terms of money. Many journals are economically difficult to sustain. Our academic exchange is held to a minimum. Obviously, education is also done behind the front line. Our education budget is too small in the national economy and the teacher's pay is too low. These are problems that have to be overcome.

To make the economy scientific and to economize science is a correct policy. When implementing this policy, however, we not only must serve today's economy but also must serve tomorrow's economy. Therefore, we should properly proportionate among the first, second, and third lines. The leaves of a tree produce nutrients on the front line. A portion of the nutrients is consumed there. Another portion is delivered to the root through the bark which sends water and minerals to the branches through the xylem. If the leaves are too selfish, it will lead to serious consequences. There is no harm if we experiment a little. If the bark is peeled, the tree initially appears to be flourishing. However, it will die very shortly. Of course, this is an extreme case. We should not go to extremes. We should also pay attention to the fact that Chinese computer professionals are attracted by an economic force to work on adding Chinese characters to foreign made microcomputers to be later dumped into the domestic market. On the long run, the technical gap between China and other advanced countries will widen. We will become a technical colony. This is an alarming trend. We should immediately organize ourselves to take protective measures to make intelligent machine a national key issue to improve the standard of Chinese computer technology.

3. Labor Value

The labor value of science exists. It is finite and can be calculated. Marx believed that the value of a product is the average social labor required to manufacture it. When he talked about the compensation of workers in a capitalist society he said that the compensation should support the livelihood of the worker. Furthermore, it should enable the worker to receive the education and rest to maintain his job and to allow him to bring up a family. In summary, the compensation is a cost to allow him and his descendant to continue working as laborers. This cost is far less than the value of the product. The difference is called surplus value.

According to the principle of Marxism, the labor value of knowledge should at least be equal to the cost to ensure that an intellect can continue to produce intellectual products. These conditions are:

(1) Study and research conditions. In order to perform scientific research, a person must attend grammar school, high school, and college. Some even studied for their master's and doctoral degrees. Science and technology changes ever so rapidly and the pace of reeducation is so fast. Some disciplines existed for a dozen years. A expert's skills might become obsolete in 4-5 years if he does not absorb new information in his field. Therefore, they should have the opportunity to study and exchange information. They should be given the necessary conditions to perform experiments, as well as quiet offices and studies.

(2) Comfortable living conditions. The work of a scientist is a life-long race. His time is very valuable. If we want him to take the lead, we should not allow him to waste his time on doing household chores and waiting for crowded buses.

Only with these conditions can an intellect remain an intellectual and continue to produce intelligent products. The price to pay to ensure these conditions is very limited. The labor value of science is far more than this cost. We should be willing to pay this small price for a priceless treasure. Policies should be implemented to organized qualified people to develop intelligent computers.

In order to assure intellectual work, the conditions described above are not sufficient. We should also have good social conditions, including firm leadership and long-term support. In addition, we need close collaboration from all personnel concerned. Without such social conditions, the research will run into obstacles.

The three types of values of science are discussed above. However, money is not the only thing in science. There should also be some dedication. The development of intelligent computers concerns the future of our nation. At present, some developing nations are just starting because it is an unique opportunity. Japan mobilized 40 "scientific warriors" to work on an ambitious 10-year Plan and who have sworn to succeed. In the development of intelligent machine, if China also concentrates its talents, develops a plan and works hard, we should not be too far behind other countries. It would be possible to obtain some useful results in a short period of time. If we hesitate, we will regret later. With regard to this important issue, we should be determined to re-enter the leading role in science and technology in approximately 15 years.

12553/9190
CSO: 4008/1029

NATIONAL DEVELOPMENTS

GUANGZHOU'S DEVELOPING TECHNOLOGY MARKET

Guangzhou NANFANG JINGJI [SOUTH CHINA ECONOMY] in Chinese No 5, 85 pp 35-37

[Article by Zhang Jinzhi [1728 6930 2535]: "The Rapid Growth of Guangzhou's Technology Market in Recent Years"]

[Text] Major Forms of the Guangzhou Technology Market

The technology market in Guangzhou has been growing very rapidly in recent years. As reform and the open door policy develop in depth, in particular, technical trade has become an important part of the socialist unified market. At present, technical trade in Guangzhou mainly takes the following forms:

(1) Software market. Information is disseminated and ties established primarily through all kinds of academic seminars, public lectures, data circulation and consulting services. More specifically:

1. organizing a variety of technical and academic lectures and technical training courses. As a preliminary form of the technology market, they cover a broad area and are relatively widespread. The Guangdong and Guangzhou science and technology commissions alone have organized more than 700 lectures on advanced foreign technology and other academic subjects in recent years, attracting over 80,000 attendants from all over the country. Since 1980, the Guangzhou Science and Technology Exchange Clearinghouse, in cooperation with scientific and technical personnel from Hong Kong, Macao and other parts of the world, has conducted 60 courses of all types (including foreign languages and management) with a combined enrollment exceeding 11,600. The Guangzhou Chinese Medical College began offering international acupuncture courses in 1980 which have drawn a total of 300 students so far from 45 nations and regions, including Japan, the United States, and Australia.

2. developing all kinds of scientific and technical consulting and gradually putting together a citywide scientific and technical consulting network made up essentially of academic institutions supported by technical consulting organizations in various departments. According to incomplete data, there are now 81 assorted technical consulting research institutions, consulting service centers, consulting service companies and consulting service agencies in Guangzhou. The scope of consulting includes the import of technology,

equipment and capital; investments; the development of new products and new technology, and business, etc. In 1984 more than 1,000 consulting projects were launched, boosting economic results by more than 10 million yuan.

3. sending scientific and technical personnel abroad on study and exchange missions. In recent years, the provincial and municipal science and technology commissions dispatched 40 missions involving 2,000 people to Japan, the United States, Australia, Hong Kong and Macao for study purposes. At the same time, the municipality played host to 400 groups consisting of 2,000 foreign visitors from the scientific and technical community who stopped over at Guangzhou during their China tour.

4. disseminating information through the press, periodicals and journals. Between them, the Guangdong provincial Science and Technology Publishing House, major colleges and universities, research units and academic organizations put out 300 specialized journals and miscellaneous publications and millions of copies of books a year. The Guangdong provincial Science and Technology Library, Zhongshan Library, Guangzhou Library and the libraries of various colleges, universities and research units subscribe to over 10,000 journals in science and technology and have several million science and technology books in their holdings. The Guangzhou branch of the China National Publications Import Corporation has established long-term business relations with 8,000 publishers, book dealers, and academic research organizations in more than 100 nations and regions and provides scientific and technical publishing services both inside and outside the province.

(2) Hardware market. Technical exchange is mainly effected through all manner of scientific and technical achievement exhibitions, seminars and brainstorming sessions to tackle a particular technical problem jointly. Specifically:

1. The hallmark and chief organizational expression of the Guangzhou technology market is scientific and technical achievements exhibitions, exchanges and fairs of every description. The first scientific and technical achievement exhibition and exchange in the Guangzhou area was held in 1982 at which 85 colleges, universities and scientific research units displayed a total of 1,292 achievements, of which 70 were registered for transfer, including 15 for which transfer contracts were signed on the spot.

2. All kinds of activities have been initiated to import technology from abroad, establish cooperation with the interior, break down regional and departmental barriers and speed up the transfer of science and technology from scientific research units to production units, from the military to civilians, from coastal areas to the interior and from overseas to China. Economic and technical cooperation projects currently under way, including those in technology transfer and compensation trade, assume myriad forms. According to incomplete data, city-wide, 283 contracts were signed involving Chinese-foreign joint ventures and compensation trade from 1979 through 1984, along with 14,000 contracts for processing and assembling using imported materials and parts. During the same period, 150 production lines and tens of thousand pieces of advanced equipment were imported. Guangzhou has concluded 1,300 economic and technical cooperation contracts and agreements valued at

390 million yuan with 21 provinces, municipalities and autonomous regions. It has imported 31 technical items from and exported 21 technical items to other provinces and municipalities. The municipality has also set up 21 raw material bases.

3. All kinds of technical brainstorming sessions have been held. Over 300 brainstorming and demonstration sessions, large and small, have been held for the 141 key scientific and technical projects given top priority by the municipality in 1984.

4. Scientific and technical stores and various scientific and technical trade organizations have been established. Guangzhou currently has 343 technical service and trade organizations and 39 technical stores. Built by the Guangzhou Science and Technology Development Corporation on 600 square meters of land to the east and north of Yiyuan in Haizhu Square, the 39 stores display, sell and transfer technical achievements, offer technical consulting offices, conduct training and organize technical project negotiations, apart from selling and buying advanced domestic and foreign teaching equipment, medical instruments, computers, home appliances and photographic equipment. They attract droves of customers from inside and outside the province and do a booming business, effectively promoting scientific and technical exchanges and technical trade. Less than 6 months after opening their door, sales already exceeded 9 million yuan and current daily sales reach 50,000 yuan and more.

(3) Unitary markets which sell means of production and means of subsistence under one roof. Such markets mainly comprise fairs and exhibitions for means of production and means of subsistence and "department stores" selling articles of daily use. These multifarious markets where the full gamut of means of production and subsistence can be bought are in effect exhibitions cum trade fairs for new products, new technology and new processes. Competition between new products is in reality competition between different technologies.

Socioeconomic Significance of Technology Market

The appearance of the technology market has done much to regulate the relations between science, technology and the economy, break down the restrictions which have held back scientific and economic developments, quicken the pace of the reform of the scientific and technical system, spur the exploration of new technical terrain and fuel economic prosperity.

1. It has enhanced the social value of knowledge and technology. Owing to the plethora of technical transactions, the value of technology has achieved recognition, intellectuals and mental labor have won respect and "degrees" too have now become valuable. Mastering technology, getting an education and pursuing knowledge therefore have become the order of the day. According to preliminary statistics, 548 high schools and technical schools for employees, with a combined enrollment of 380,000, were established by various industries and trades in the city in 1984 to meet the educational and technical needs of their workers. In addition, there are 160 schools of continuing education and night schools, enrolling over 50,000 students in all. About 330,000 people have attained junior high level after receiving continuing education and

passing an examination, accounting for 61 percent of all workers in the municipality who should go through such training. Among its workers who should receive continuing education at the senior high level, 250,000, or 69 percent, have reached such a standard after passing the necessary examination.

2. It has brought scientific research and production even more closely together and popularized the application of scientific research achievements. According to statistics on 30 specialized research institutes under the municipal government, of the 125 research projects completed in 1984, 87, or 69.6 percent, were popularized and applied the same year, representing an increase of 20 percent over 1978.

3. It has promoted efficiency within scientific research units and boosted their incomes, with a corresponding improvement in their research conditions. Previously it took a technical worker at the provincial Electronics Research Institute an average of 18 years to come up with an achievement. In 1984, of the 15 projects which the institution had won bids to undertake, the largest one was completed within 19 months by just 5 people, and 3 projects were completed before the year was out. Statistics show that the 39 municipal specialized research institutes earned 6.6 million yuan in 1984, up almost 200 percent and 65.8 percent respectively over 1981 and 1983. According to 1984 year-end data, of the 37 development and applications institutes under the municipal government, 21 have put up new scientific research buildings, thus tentatively solving the problem of a lack of intermediate testing sites.

4. It has cleared the channels of technology transfer and promoted extensive technical cooperation and economic linkages. Through market exchange, a large number of new technologies and achievements have obtained outstanding economic and social results. In the wake of the circulation of technical commodities, a network of cooperative relations has gradually taken shape. According to statistics at the end of 1984, the municipality has established ties with 200 colleges, universities, scientific research organizations, academic bodies, manufacturers and companies in more than 20 nations and regions. Domestically it has also entered into cooperation with the colleges, universities, scientific research organizations and enterprises in 21 provinces, municipalities and autonomous regions.

5. It has promoted the rational mobility of intellectuals and scientific and technical personnel. Since its founding in 1983, the provincial Skilled Personnel Circulation Center has carried out its job as an "intermediary" and "go-between" in personnel circulation enthusiastically. By the end of 1984, 4,500 specialized personnel of all kinds have registered with it, of whom 1,300 have tentatively been selected by 400 employing units, including 400 who have completed their transfer formalities. At the 5-day Guangzhou skilled personnel circulation conference in August 1984, 8,700 people asked for a transfer and 3,100 of them received preliminary job offers from employing units, including 200 who completed their transfer procedures soon after the conference.

Some Suggestions For Further Invigorating the Market

Guangzhou has only taken the first step toward developing its technology market. There remain many urgent problems which we must examine and resolve in earnest if we are to ensure effectively its healthy and successful development.

1. Strengthen the macro management and guidance of the technology market. Already Guangzhou's market takes a multitude of forms. Whether they are permanent or temporary, specialized or comprehensive, and whether they are run by a region, a unit, a public organization, a collective or an individual, we must treat them alike, giving all of them encouragement and support. We should gradually establish and perfect the rules and regulations governing the market and draw up as soon as possible regulations for scientific cooperation contracts, legislation on scientific and technical consulting and circulation procedures for scientific and technical personnel, etc., in order to stimulate the development of the market.

2. Step up research into technology market policies. As the technology market is a novelty in China, its birth and growth raise many policy issues which we must examine and explore in theory and practice, eg., the commodity value of technology, prices, the distribution of the benefits of technology transfer and so on. Banking institutions and finance and tax agencies should facilitate the market with preferential treatment.

3. To further invigorate the technology market, we must reform and improve our own work in the development, acceptance and introduction of technical achievements in light of the need to develop the technology market and speed up the commercialization of achievements.

(1) Colleges, universities and scientific research units must gradually outgrow the "planned scientific research model" and adopt a "scientific research as a business model." They must firmly foster the concept of the market, business values and a strong sense of competition, establish and perfect their own business mechanisms and technical service systems step by step, and do their best to produce high-quality and popular, marketable technical commodities for the technology market.

(2) Production enterprises should intensify their consciousness of using new technology. This is of decisive importance to the development of the technology market. Basically the prosperity of the technology market depends on the technical needs of enterprises which, in turn, are closely related to government policies toward the use of new technology and the enterprises' own economic vitality. Hence we must encourage and support enterprises to adopt new technology and develop new products with the right policies. Enterprises, for their part, must devote major efforts to augmenting their ability to absorb and develop technology. To that end, they must rely on science and technology to renew their products continuously and solve a host of problems in industrial production, eg., those relating to quality, the consumption of raw and other materials, productivity and equipment.

(3) We must develop and perfect more technical exchanges, trade, consulting, service, information and notarization institutions of all kinds, put together and train a contingent of scientific and technical personnel and managers and gradually establish the technology market as a trading system.

4. Uphold the open door policy, integrate the domestic technology market with the one overseas and make the absorption, assimilation, innovation and transfer of imported advanced technology an important aspect of the task of developing a technology market with Guangzhou characteristics. We must combine the import of foreign technology and capital with the establishment of economic linkages with the interior and give technical personnel access to knowledge from abroad, in this way making full use of Guangzhou as a city "with a dual orientation, to the world and to the nation, and as a link between the two."

12581
CSO: 4008/2062

NATIONAL DEVELOPMENTS

LIAONING PLANS INCREASE IN TECHNOLOGY IMPORTS

OW310812 Beijing XINHUA in English 0727 GMT 31 Jan 86

[Text] Shenyang, 31 January (XINHUA)--Northeast China's Liaoning Province plans to spend twice as much hard currency importing technology between 1981 and 1986 than during the previous 5 years.

Liaoning, a major heavy industrial center in China, will spend 3 billion U.S. dollars introducing 3,000 items of technology over the next 5 years, said an official of the provincial Planning Commission here today.

Foreign funds will comprise a third of this amount and will be introduced in such forms as loans, Sino-foreign joint ventures, cooperative businesses, compensation trade and leasing.

Foreign technology and equipment will be used to upgrade 275 major enterprises and develop 450 new products in such areas as metallurgy, electronics, machine-building, chemicals, energy, building materials, textiles and light industry.

Moreover, foreign funds will be used to speed up construction of harbors at Dalian, 1 of the 14 coastal open cities, and other ports. Three new airports will be built in the provincial capital of Shenyang, Dalian and Chaoyang, respectively.

Technology imports are expected to enable 70 percent of the province's machinery to meet the advanced international standards of the late 1970s and early 1980s by 1990, compared with the present 32 percent.

The electronics industry will concentrate on developing microcomputers and microprocessors, while the Anshan Iron and Steel Company, one of China's largest, and other steel makers will import new rolling mills to boost output.

/12232
CSO: 4010/2010

NATIONAL DEVELOPMENTS

NDSTIC TO EXPERIMENT WITH NEW RESEARCH APPROPRIATION SYSTEM

Beijing BEIJING KEJIBAO in Chinese 8 Jan 86 p 1

[Text] An experience exchange conference on the restructuring of the defense scientific and technical system was recently convened in Beijing by the National Defense Science, Technology, and Industry Commission. Leaders from the various military industrial ministries, various arms of the services and some research institutions and factories which have been carrying out pilot projects attended the conference to talk about their experience and discussed ways to restructure more effectively the defense scientific and technical system.

In line with the CPC Central Committee resolutions on restructuring the economic and scientific systems, and the spirit of relevant government regulations, the reform of the defense scientific and technical system has made new progress in breadth and depth over the past year or so. Particularly effective have been its trial reforms to adopt a paid contracting system. New experience has been gained in this area.

The core of the present effort to reform the defense scientific and technical system is to replace the appropriation system of defense research trial-manufacturing funds with a paid contracting system in order to meet the demands of developing a planned commodity economy and the commercialization of research achievements. Such a change will make it easier to match scientific research trial-manufacturing funds with tasks and ensures that the principle put forward by the Central Military Commission -- "shorten the battlefront, stress our priorities, tackle scientific research aggressively and quicken the pace of modernization" -- is realized. It will also help delineate the boundaries between the economic and technical responsibilities of research and development departments, on the one hand, and departments which apply the results, on the other; mobilize the two kinds of initiative and facilitate the overall planning of scientific research units so that they can devote some of their resources to civilian research and transfer military technology to the civilian sector. Under a paid contracting system, scientific research units will enter into agreements directly with departments which apply their results. Legally their relationship is adversarial. In terms of work, however, they are a partnership devoted to the completion of a joint research project.

12581
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NATIONAL DEVELOPMENTS

PRC CONTINUES TO STRENGTHEN BASIC RESEARCH

OW040740 Beijing XINHUA in English 0706 GMT 4 Mar 86

[Text] Beijing, March 4 (XINHUA)--An official from the science and technology leading group under the State Council told XINHUA today that China will continue to strengthen basic research, ensuring technological reserves for the country's economic and scientific development.

Last Thursday, the State Council issued a circular on establishing a national natural science foundation to support basic and applied research.

In line with the country's plan for science and technology development, he said, the science foundation will work out guidelines for applications and give instructions to basic research projects so as to make them comply with the country's long-term development plan.

He said special attention should be paid to those basic research projects with applications for developing China's natural resources.

The establishment of the national natural science foundation is an important measure of the changes in the science funding system, as required in the decision on reforming the scientific research management issued by the Chinese Communist Party Central Committee in March, 1985.

The official said the state allocations will be the main source of funds for the foundation, but contributions from units and individuals at home and abroad will be welcome. Funds for the foundation will be increased faster than the rate of increase of regular state revenues.

The foundation will organize scientists and specialists to appraise applications from across the country and support those projects of vital importance.

All scientific workers in the country will be eligible to apply for grants from the foundation, in accordance with the guidelines and relevant regulations worked out by the foundation, the official said.

The establishment of the foundation will make good use of the present limited spending on scientific research, bring the initiative of scientific workers into full play and raise the academic level of research projects, he added.

/12712
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NATIONAL DEVELOPMENTS

HEILONGJIANG DEFENSE INDUSTRY HELPS INVIGORATE LOCAL ECONOMY

Beijing RENMIN RIBAO Overseas Edition in Chinese 29 Jan 86 p 3

[Article by Wu Xiaodong [0702 0879 2639]: "Heilongjiang Defense Industry Produces Civilian Goods"]

[Text] The vigorous drive by the defense industry in Heilongjiang to achieve military-civilian integration has been highly successful. In 1985, over 60 percent of the industry's total profits were derived from civilian products.

With its modern equipment and formidable technological prowess, Heilongjiang's defense industry has gradually shifted from serving national defense exclusively to contributing to key strategic aspects of the national economy and invigorating the local economy. Exploiting its own strengths, it has actively modified its product mix and successively developed over 200 types of civilian products. The civilian output value of military industrial enterprises rose 3.4-fold last year over that in 1980.

In developing civilian goods, the military industry goes out of its way to contribute to the various trades and industries in the national economy. To help energy exploitation and the transportation industry, they make the Yun-12 aircraft, mini cars, coal mine hydraulic supports, oil drilling equipment and graders, among other things; for agriculture, they make small tractors, large shed frames, flour-milling machines and oil presses; for light industry, they make aluminum alloy, bicycles, washing machines, liquid petroleum gas containers, stoves and sports equipment; for construction and other trades, they make tower cranes, bulldozers, construction equipment, dies and aluminum products. Military industrial enterprises insist on quality first; over the past few years they have captured 1 National Gold Quality Prize, 3 Silver Quality Prizes and 29 ministerial or provincial good-quality prizes.

12581
CSO: 4008/2061

NATIONAL DEVELOPMENTS

PROPOSED MEASURES TO MAKE FUZHOU FUJIAN'S SILICON VALLEY

Fuzhou FUJIAN LUNTAN [FUJIAN FORUM] in Chinese No 5, 5 May 85 pp 29-31, 39

[Article by Lin Qiping [2651 0366 1456]: "Fujian To Establish Its Own 'Silicon Valley'"]

[Text] The success of Silicon Valley has led to the spread of the silicon valley pattern of development and its imitation all over the world, the emergence of a veritable "silicon valley craze." This new technological revolutionary trend, with electronics as its core, truly deserves our conscientious study.

I

We in Fujian Province must establish our own silicon valley.

1. Establishing a silicon valley will enable us to skip the traditional developmental stages and move to the forefront of China. In nationwide perspective, Fujian is a rather backward province, both industrially and agriculturally. If we want to "move to the forefront of the country" within a short period of time, we have to skip the traditional developmental stages; the only reliable method these days to do so is to employ new advanced technologies in technologically transforming the traditional industries and trades, and, for that purpose, to concentrate on one industry as the pioneering sector and breakthrough point, the development of which would then provide the impetus for technological transformations in all other industries. This industry can only be the electronics industry. The U.S. magazine SCIENTIFIC AMERICAN is entirely justified in calling the electronics industry "the wheel of the 20th century" and "the bridgehead of the new industrial revolution." In its application, electronics is a general technology of the widest scope. All such areas as the rapid development of equipment for the automation of production processes, improvements in management and control in industry, commerce, finance, and in government organs, innovations in medical, pharmaceutical and scientific instruments, as well as modernization of information, broadcasting, and television networks, all rely on electronics. Its development will spur on the rapid development of all other industries and will be an important factor that could possibly allow us to skip the traditional developmental stages and move on to the forefront in China. Development of electronics is particularly suited to the special

characteristics of Fujian Province, which, although rich in natural resources, lacks the raw materials needed for the steel industry and lacks such sources of energy as coal, electric power, and petroleum, while the electronics industry, on the other hand, requires little energy and few materials. The development of the electronics industry requires a region with pioneering quality, which will constitute a core from which influence will radiate in all directions, spurring on developments in other regions. This, then, is what we want to develop as our own silicon valley in Fujian Province.

2. Establishment of a silicon valley will enable Fujian Province to play a special role in opening up China to the outside world. In Fujian Province, the electronics industry had its start in the late 1950's. It has developed rapidly and achieved a new breakthrough particularly since the initiation of the open door policy. As to the value of its production, in 1981 Fujian placed 16th among the nation's electronics industries, jumped to 8th place in 1983, and doubled the value of its production in 1984 compared to 1983, occupying 6th place in the country, electronics ranking third among Fujian's major industries. There are now over 500 types of products, which fairly cover the whole area. We therefore find in Fujian Province a certain foundation for the production and technology of an electronics industry. If we develop our own silicon valley in Fujian Province, it is bound to promote rapid further development of the electronics industry and other newly arising technologies in Fujian, and may quite possibly raise our electronics industry to an even more prominent position in China, so that it will become an important window and base of national significance for the importation and development of new technologies, centering on electronics, effectively play a special role as a provincial share in the opening up to the outside world, and greatly contribute to China's four modernization projects.

3. Establishing a silicon valley has been the strategic measure employed by Third World countries and territories in their efforts to move into the world arena with the development of their economies. The development of the electronics industry in the world, although mainly concentrated in such developed countries as the United States and Japan, is now an area where developing countries are doing all they can to catch up. Those that started early in this race were China's province of Taiwan, South Korea, Singapore, and Brazil. They all proceeded, one after the other, by establishing their own silicon valleys according to the pattern of the original Silicon Valley. In 1979 the Singapore government set out to establish a science and technology park at Kentegang, near Singapore University, as an entity that would facilitate the importation of new technologies. Taiwan also began, toward the end of 1980, to establish a science and technology park at Xinzhu for the importation of most advanced foreign technologies and to develop new technology-intensive industries. Up to now over 60 percent of the more than 30 enterprises approved for investment in the park were electronics and information processing enterprises. If the province of Fujian, an advance outpost of this Third World country of China, wants to attain worldwide significance in its efforts to open up to the outside world, it must also provide a base for an electronics industry and for high technology production, which means that it must also establish its own silicon valley.

II

Where should Fujian's silicon valley be located? In my opinion, it should be established at Fuzhou, a place with many favorable conditions for rapid development.

1. Fuzhou has a definite foundation as an electronics industry base. Currently, there are 108 enterprises of the electronics industry system throughout the province, of which about one-third are concentrated in Fuzhou. The electronics industry employs 22,157 staff and workers, and the Fuzhou Electronics Industry Bureau alone employs 6,716 of them, which is also about one-third. According to 1982 statistics, the output value of Fuzhou's electronics industry accounts for 43.13 percent of that of the whole province, placing it first in Fujian. Fuzhou's electronics industry is of decisive economic importance for the province and for the entire industrial system of Fuzhou itself. In 1985 its output value will place it among the top three industries of the municipality. In 1986 the profits that it will turn over to the treasury will be equal to the total amount turned over in 1983 by all municipality-run industrial enterprises. By 1990 its output value will be equal to the total output value of all municipality-run industries in 1983, reaching 1.2 billion yuan, which will be more than twice the total output value of 470 million yuan achieved by the entire province's electronics industries in 1983.

2. Fuzhou has a very strong scientific and technological work force. The electronics industry is "an industry based on scientific research," a "knowledge-intensive industry," or "technology-intensive industry." Its development is closely bound up with the foundation available in scientific research conditions and in scientific and technological strength. The province has five research institutes specializing in electronics, one each in the field of electronics, optics, computers, semiconductors, and communications, and one electronic products control and inspection office, all located in Fuzhou. The Fuzhou Electronics Industry Bureau employs 500 of the 1,866 engineering and technological personnel, and if the provincial electronics enterprises located in Fuzhou were included, the figure would be more than half. Fuzhou also has universities and colleges, such as Fuzhou University, Fuzhou Normal University, etc., which have specialized instructional and research establishments for electronics, optics, semiconductors, computers, and other high technology, and which have indeed already achieved outstanding successes in their scientific research, such as the HCP system developed by Fuzhou University, which is a first in advanced software tool manufacture in China. Fuzhou has also 36 scientific research organs, 450 high-ranking specialized research fellows, and 18,800 specialists in the natural sciences--altogether a large science and technology force, constituting a definite capacity for scientific and technological development and for the comprehensive handling of key projects, well capable of rapidly applying scientific and technological research results and absorbing and digesting advanced science and technology imports from abroad, and also capable of pursuing inventions and innovations.

3. Fuzhou has several excellent key electronic enterprises, some of them renowned at home and abroad, such as the Furi Company, which is the first

Chinese-Japanese joint venture enterprise in Fujian. In quality its television sets equal any similar type manufactured by Hitachi, and the sets have indeed been able to penetrate domestic and foreign markets. The productivity of the entire work force ranks at the top in this line of industry throughout all of China. The Fuzhou Computer Factory is the largest factory in the whole province; it is manufacturing microcomputers and calculators. The calculators are a staple product of Fujian's electronics industry, accounting for one-quarter of the total national production, and considered the best in the country. There is also the Fuzhou Radio Factory which manufactures the "191-model digital multimeters," a production that fills a gap in China's production of testing equipment. These excellent key enterprises will promote developments in a large number of cooperating factories and component plants, and will exercise leadership in the development of Fuzhou's electronics industry and other high-technology industries.

4. Fuzhou has a transport and communications network that extends in all directions. Good access to information is an important condition for the development of electronics and high technology industries. Fuzhou has well-developed communications and an even more advanced telecommunications system. The city has imported from Japan a complete set of equipment for a computerized time-division exchange system for a 10,000-channel city telephone system and for a 500-channel long-distance telephone system, enabling automatic direct dialing to places within China and abroad, and establishing long-distance telephone connections with various large cities in 41 countries, thus facilitating quick transmission of information.

All the above-mentioned favorable conditions provide Fuzhou with a sound initial basis for the development of electronics and high technology industries and make Fuzhou a favorable place for the establishment of a silicon valley. However, in order to achieve the development of an electronics and high tech industry of domestic and foreign significance, which will also be capable of spurring on the electronic industry of the entire province, and which will also turn Fuzhou into a pioneering district that will stimulate an upswing in all other industries throughout the province, it will of course be necessary to employ many further measures.

III

The following measures should be adopted to establish a silicon valley at Fuzhou:

1. It is necessary to determine a developmental plan for an intermediary period. In view of the characteristics of the Fuzhou electronics industry--its many small factories and large number of component factories--it is necessary, when determining the plan for the intermediary period, on the one hand, to base oneself on the presently available technology imports and technical transformations so far effected in the electronic enterprises, and to proceed in three stages. First stage: stress on the assembly of components, importation of advanced production lines for components, thereby laying a solid foundation. Second stage: emphasis on the readjustment of all machinery, importation of key equipment, key parts and random parts, the

production of complete electronic equipment of an advanced nature. Third stage: emphasis on prime items, best hot-selling goods, such as color TVs, electric refrigerators, video recorders for industry, microcomputers, etc., to bring about vigorous development and an economic upswing. On the other hand it is also necessary to pay serious attention to the opening up of new territory, to be conceived as: (1) Preparations for the establishment of an electronics industry university, mainly for the purpose of training postgraduate students and for the pursuit of scientific research. (2) Establishing a research institute for the development of software, to assume the tasks of scientific research development, development of industry, technological and economic research, technological projecting for all the various trades and industries, research in computer applications, and the gradual building up of a software force, turning the Fuzhou region into a software development center.

2. Pursuing a three-pronged course, accumulating capital through a variety of channels. The electronics industry requires large investments; hence it is called an "investment-intensive industry." Operation of a large-scale factory requires the expenditure of hundreds of millions of yuan. Following World War II, the major capitalist countries, especially the United States, Japan, Great Britain, and the FRG, invested at a high rate--about 3 to 5 percent of their GNP--in their electronics industries. For the last 10-odd years, the rate at which investments in the U.S. electronics industry increased exceeded the rate of increase in investments of the entire industrial sector. Turning Fuzhou into the silicon valley of Fujian Province within a short period of time requires large capital funds. However, raising large investment funds within the province and within the city would currently be very difficult; such funds must be sought through a variety of channels and should be pursued in a three-pronged way: On the one hand, capital may be absorbed from sources inside and outside the province, including capital of the state, of the collectives, and from individuals. On the other hand, joint operations with foreign enterprises should be initiated. Among all cases of importations by the Fuzhou Electronics Industry Administration during 1984, 11 cases were joint venture operations. We have by now accumulated a certain amount of experience in this respect. In the future we shall pay attention not only to the digestion, absorption, and conversion to domestic production of the imported items, but also to importing certain items that are of high technological level, that are difficult to manufacture, and that are highly sophisticated. And in yet another respect, when foreign enterprises invest their own funds to operate electronics industries in Fuzhou, the key target for our efforts to obtain such investment funds should be enterprises set up overseas by Chinese scientists of some achievement and most of the famous United States and Japanese high tech companies.

3. Importance must be attached to the transfer of technologies. An important experience gained from the success of Silicon Valley is the implementation of a policy of effecting technology transfers by a close linkage between universities and enterprises. In this manner the technology is transferred from the classrooms of the universities and from research offices to the various enterprises, in a kind of fast conveyor belt of knowledge for transports from institutions of higher learning and scientific research organs to the industrial enterprises, so that the technology can be speedily and

effectively used in actual production. In our efforts to establish Fuzhou as the silicon valley of Fujian Province we must fully assert the role of the universities and relevant research organs in Fuzhou City. For this purpose: (1) The Fuzhou University, being an industrial university with a very strong technical curriculum, must strengthen its research in latest technologies and must, furthermore, speedily transfer any achievements of its research to the enterprises. (2) Universities or research organs with suitably favorable conditions may, in an accurate assessment of the market situation and staying within the means presently available to them, start up by themselves enterprises appropriate to the needs of the times and develop electronic products required in the international market. (3) Universities or research organs may set up joint ventures with enterprises, having the enterprises invest capital and the university invest the intelligence of its personnel for an effective integration of capital and intelligence.

4. Importance must be attached to intelligence work and access to information. An enterprise that lacks advanced technology is of course in jeopardy, but more dangerous still is an ineffective state of its intelligence gathering and of its access to information. Our efforts to establish Fuzhou as the silicon valley of Fujian Province makes it absolutely necessary to pay strict attention to intelligence gathering and access to information. It is necessary to: (1) Establish a modern intelligence and information center, gather and study the production and marketing conditions of the electronics industries in the domestic and foreign markets, and their technological data, research achievements, etc. (2) Developmental strategy and import activities of the electronics industry must be based upon intelligence and information, to prevent irrational operations. (3) Based on market information and on scientific and technological information, efforts must be directed toward the improvement and updating of electronic products; we must strengthen the manufacture of new products in complete sets, change the composition of our products, and develop components and adjust machinery to form complete sets.

5. We must go all out in the successful utilization of intelligence, because Fuzhou's electronics industry now consists to a large proportion only in the assembly of imported parts, has a weak foundation, poor flexibility to meet changes in the situation, and is, furthermore, still rather backward in its production technology. Under these conditions, speedy development can only be achieved by going all to successfully utilize intelligence. This may be conceived as the need to proceed in the following directions: (1) To bring in, in a planned manner, highly qualified foreign technical personnel, placing special emphasis on bringing in Chinese of real ability and learning and scientists of Chinese descent. (2) To bring in from outside of Fujian Province a number of technical talents of the electronics industry and to import most advanced technologies. (3) To send a number of technical personnel, known to be highly devoted to their work, for advanced training to countries with highly developed electronics industries, such as the United States, Japan, and the FRG. (4) To strengthen supplementary general education and technical training of staff and workers, especially of young workers; organize staff and worker's participation in studies at electronics universities, vocational universities, and correspondence universities; organize advanced studies and training of technical personnel; raise the

overall technological quality of all staff and workers and of the scientific and technological work force.

6. Effectively implement a division of labor between the different factories. The electronics industry faces the fiercest competition in the international markets. Since we intend to establish Fuzhou as the silicon valley of Fujian Province, its electronic products must be targeted for the international markets; our opponents in the competition are, therefore, the advanced electronics industries of the various countries of the world. That makes it necessary to institute a division of labor within the province, and especially within our region; there must be no mutual competition for goods that are easy to sell. In the original Silicon Valley many different companies vie with one another to achieve one identical objective, while only one will in the end come out victorious. The others will only have paid a huge price and be left to bemoan their fate. This is a mortal defect that capitalism cannot overcome. Ours is a socialist state; we can effect macroeconomic regulation, allot each factory its share of work, and concentrate our strength on efforts to give a good account of ourselves in international markets.

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NATIONAL DEVELOPMENTS

'SPARK PLAN' IMPLEMENTED IN XINJIANG

Beijing RENMIN RIBAO Overseas Edition in Chinese 26 Dec 85 p 3

[Article by Bei Feng [0554 7364]: "Xinjiang To Launch 'Spark Plan' Projects"]

[Text] It has been learned from relevant departments that the Xinjiang Uygur Autonomous Region has begun to implement the state's "Spark Plan" and is selecting contractors for three projects assigned by the central government -- the development of the Hamie melon family of products, the integrated development and utilization of bluish dogbane and the artificial propagation of licorice root. In line with the spirit of the plan, and to complement it, the autonomous region is discussing tentatively the drawing up of a group of scientific and technical development projects which require little capital, pay off quickly and are suited to the characteristics of local enterprises.

Formulated by the State Science and Technology Commission and approved by the State Council, the "Spark Plan" is aimed at tackling the low technological standard and poor competitiveness of rural, township, small and medium-sized enterprises, reducing the threat to their market posed by the invigoration of large enterprises and laying the foundation for local economic development. The implementation of the "Spark Plan" will funnel science and technology toward the vast countryside and significantly quicken the pace of the development of rural and township enterprises.

Under the "Spark Plan," the central government, provinces, autonomous regions, prefectures and counties regularly propose a number of projects which meet domestic and international demand and have a short turnover period, require little capital and produce quick economic results, the idea being to make them part of a systematic network of projects. Whenever a batch of achievements is ready for popularization, they will be popularized so that science and technology are disseminated as soon as possible. At the same time, the government will support a large number of demonstration enterprises and integrated bodies to increase the ability to absorb and disseminate technology and strengthen the organizational base of the technology market. A meeting has recently been held by the relevant agencies in Xinjiang to make plans for resource surveys in various localities and come up with feasible development projects for inclusion in the overall development plan of the region. In addition, the three projects assigned by the state have been included in the "Spark Plan" after verification by Xinjiang's science and technology agency.

A bidding system will be adopted for the region's "Spark Plan." The required funds will come from the state, localities and enterprises. If necessary, foreign software may be imported, but in general no hardware will be purchased from abroad.

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NATIONAL DEVELOPMENTS

BRIEFS

CONTINUING EDUCATION IN FUJIAN--In light of the urgent needs of scientific and technical personnel, the provincial Science and Technology College for Advanced Studies conducted a total of 90 courses in the "Sixth 5-year Plan" period to "make good the gaps in their education and training and bring them up to date with the latest knowledge." The courses, which took a variety of forms, provided systemic continuing education for 3,929 senior-, middle- and junior-level scientific, technical and managerial personnel in the province. So far 2,393 professionals from all trades and industries have received single-subject graduation certificates. The courses have resulted in an infusion of scientific, technical and managerial experts at varying levels of expertise and in various specialties into such areas as teaching, scientific research, design and production. After graduating from the courses, many students have achieved outstanding economic and social results in their work in scientific and technical translation, foreign activities, scientific research and production management. [Text] [Fuzhou FUJIAN RIBAO in Chinese 24 Jan 86 p 2] 12581

PRIZES AWARDED--Beijing, 6 March (XINHUA)--The Chinese Academy of Sciences announced today the 20 winners of its biannual Zhu Kezhen prize for outstanding contributions in scientific field work. The prize, inaugurated in May 1983, is named after Zhu Kezhen, former vice-president of the academy and a pioneer in surveying China's natural resources. The first group of 38 scientists was given the prize in 1984. Most of this year's prize winners have participated in scientific surveys and field experiments for over three decades in glaciology, geology, geography, meterology, pedology, botanical ecology, insectology and ichthyology. Among the winners is Dai Liren, senior engineer at the institute of oceanography in Qingdao. Last year, at the age of 74, he joined a survey of the western Pacific region aboard a Chinese scientific research ship. Another is Shi Yafeng, honorary director of the Lanzhou Institute of Glaciology and Geocryology. He has conducted glacial surveys in western China over the past 30 years and has published more than 100 academic papers and reports on glaciers and landforms. [Text] [Beijing XINHUA in English 1533 GMT 6 Mar 86] /12640

CSO: 4010/2009

PHYSICAL SCIENCES

RESEARCH ON EMP NEAR TO NUCLEAR EXPLOSIONS AT LOW ALTITUDES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 10 No 4, Jul 82 pp 54-62

[Article by Lai Zuwu [6351 4371 2976], Wu Bosheng [0702 3134 3932], and Li Guanglun [0500 0342 0243]; paper received March 1981, finalized August 1981]

[Text] English Abstract: The EMP is one of the most important phenomena of nuclear explosions. The main features of EMP in the vicinity of airbursts have been researched. At the instant of an explosion, there exist both radial electric field and radiated electromagnetic field even in the source region. But the radial electric field is dominant and the radiated field is comparatively weak. This region can also be called the saturated electromagnetic field region, because the electric field reaches a certain maximum value which is not a function of the weapon yields but merely depends on the parameters of the environment. Beyond the region, the radial electric field diminishes to zero and then the radiated electromagnetic field becomes dominant. The conditions for creating the saturated field and the various EMP waveforms are discussed in this paper. On the basis of Gilinsky's assumption and considering the actual gamma time behavior instead of the "jump" wave, the expanding dipole mode may be suggested and can give satisfactory explanations of the detailed wave shapes in the early parts of EMP.

I. Introduction

Many public documents concerning research on nuclear electromagnetic pulse [EMP] have been published,[1-4] and a number of physical models of the mechanisms which produce it have been put forth, the most important of which are the Compton (or photoelectron) mechanism, the geomagnetic field deflection mechanism, and the field displacement mechanism. Since these models are all derived on the basis of definite simplified hypothetical conditions, they are frequently inadequate to explain the much more complex phenomena in reality.

This paper is based primarily on tests. It summarizes and discusses the models of EMP production in the vicinity (that is, within 10 km of the blast

center) of low altitude and surface nuclear explosions and their main characteristics, with attention to establishing a clear physical image and describing the regular phenomena (without reference to the results of a certain specific experiment).

II. Physical Models in the Vicinity of Nuclear EMP

Although there are many ways of describing the physical mechanism which produces nuclear EMP, for low altitude and surface nuclear explosions, Gilinsky's electric dipole model[2] is the closest to actuality and belongs to Compton's electric current mechanism. The results provided by this model assume that the gamma-source takes the form N_0be^{-bt}, i.e., it recognizes that the ascending leading edge of the gamma-source is a step function, and that there is a big difference between this and the approximation of the ascending leading edge of the gamma-source of an actual nuclear explosion as an exponential function, correspondingly, the early part of the EMP is overlooked. At the same time, there are certain demands on the distance between the observation point and the blast center: the distance must be much greater than the length of the moment of dipole to be able to satisfy the electric dipole hypothesis. Clearly, a nuclear explosion source region observation point does not satisfy this demand. Proceeding from the experimental results of EMP in the vicinity of nuclear explosions, we improved this model and proposed a central expansion electric dipole model which can better explain the basic phenomena of the nuclear EMP in the vicinity.

1. Physical Image of the Central Expansion Electric Dipole Model

The EMP produced by a nuclear explosion is primarily caused by instantaneous gamma rays. The average energy is about 1 Mev gamma ray, and the primary form of interaction with the surrounding matter is Compton scattering. Scattering produces Compton recoil electrons, which carry the bulk of the gamma-photon energy, primarily flying along the radius forming Compton current J. In the vicinity of the blast center, the charge separation between the Compton electrons and the parent nucleus creates a powerful electron field E, whose direction is primarily radial and is called the radial field. Along their path, the Compton electrons ionize the air producing a large quantity of secondary electrons which also are absorbed by oxygen atoms at a rate of about 10^8/s to form negative ions. At the same time, positive ions combine with electrons and negative ions at a slower rate to become electron neutral and make the electrical field disappear. Because the number of these charged electrons produced by gamma rays at the moment of the nuclear explosion are far greater in number than the number that disappear, a highly ionized region appears in the air in the vicinity of the blast center. As the distance from the blast center increases, the degree of ionization gradually decreases. Because of the existence of degree of ionization, the air around the blast center has conductivity σ. With the action of the electrical field, a conduction current σE appears. If there is no symmetry in the blast conditions, this system will radiate electromagnetic waves outward. As an approximation, this system can be treated as an electric dipole radiator. Because there is polarity opposition between the two currents in the system--the Compton current and the conduction current--the two provoke an interactive compensation.

The growth and decline between them is the basic cause of the complex phenomena of nuclear explosion EMP.

At a certain moment of a nuclear explosion, the electrical field space in the vicinity of the blast can be divided into three areas. The blast center is a plasma region in which the degree of ionization is very high; a region outside the plasma region is the saturation region, where the degree of ionization causes a dynamic balance between the conduction current and Compton current, and after the electrical field value rises to a maximum value, it no longer increases; outside the saturation region is a transitional region which increases with the distance from the blast, where the maximal value of the radial field rapidly drops from the saturation value to zero, but the radiating field value decays very slowly with the distance. These two fields gradually overlap from radial field to radiating field. Outside the transition field, the radial field is close to zero, and it only manifests a radiating field.

In the blast process, from the perspective of time, the above three areas have a process of formation and expansion outward. The process relies on the temporal relationship of the instantaneous gamma-source. According to the temporal relationship of the gamma-source assumed by Gilinsky, implying that at the initial moment of the nuclear explosion, a fixed radius plasma region and a fixed radius saturation region suddenly appear. However, in an actual nuclear explosion the gamma-flux rising approximation is an exponential function. The corresponding physical process should be: the ions near the blast center gradually rise, the central plasma region and saturation region gradually expand outward and reach a maximum radius. The corresponding moment of electric dipole distance also gradually increases to its maximum extent. Under such conditions, near some observation points the moment of gamma-flux peak does not satisfy the hypothesized electric dipole conditions but the initial period of the blast does. In the initial period of the blast, the blast center is only a very small area, its degree of ionization is very high, and the blast center can be viewed as only having a small radiating body, and only as the time increases does it gradually grow. Thus, these observation points in the early period of the blast may be taken care of by using electric dipole radiation. As the time increases, the gamma-flux rapidly grows, the moment of electric dipole also grows rapidly, and the electric dipole approximation becomes increasingly untenable, but at this time, at these observation points the radial field has already become an important contribution.

The above physical image shows that the nuclear explosion system we are discussing is an active field. Mathematically, to avoid the appearance of a singular point in the source point, it is necessary to deduct the source point and treat it as a boundary condition. We assume that in the source point there is a fully conducting sphere, and as it changes with the temporal relationship of the gamma-source, from its initially arranged radius it expands to a plasma area of several hundred meters. The boundary expansion rate is computed from the actual gamma time spectrum. Thus, observation points which are nearby in the early period of the blast satisfy the electric dipole hypothesis, and electric dipole radiation can be used to compute its radiation

field value. At the same time, there is also a rapidly growing radial field value, thus the nuclear explosion EMP of these points should be treated by overlapping the radiation field and the radial field.

2. Describing the Nuclear EMP Equations

The currents that exist in the above described system are the Compton current J and the conduction current σE. The Maxwell equation group contains differential forms for the two equations of temporal change:

$$\nabla \times E = -\frac{1}{C}\frac{\partial B}{\partial t} \tag{1}$$

$$\nabla \times B = \frac{1}{c}\frac{\partial E}{\partial t} + \frac{4\pi}{c}(J + \sigma E) \tag{2}$$

in which c is the speed of light. If the blast is axially symmetric, on the spherical coordinate system, E_φ, B_θ, and B_r are zero, and there are only components F_r, E_θ, and B_φ. According to the electric dipole hypothesis, Compton current, conduction current, and the radial field can be written as a superposition of the symmetrical and the assymmetrical parts:

$$J_r(r,\theta,t) = J_0(r,t) + \xi J_0(r,t)\cos\theta \tag{3}$$

$$\sigma_r(r,\theta,t) = \sigma_0(r,t) + \xi\sigma_0(r,t)\cos\theta \tag{4}$$

$$E_r(r,\theta,t) = E_0(r,t) + E_1(r,t)\cos\theta \tag{5}$$

$$E_\theta(r,\theta,t) = E_2(r,t)\sin\theta \tag{6}$$

$$B_\varphi(r,\theta,t) = B(r,t)\sin\theta \tag{7}$$

in which ξ is a nonsymmetrical factor, but is a small quantity. E_0 and E_1 are the symmetrical part and the nonsymmetrical part of the radial field, respectively. E_2 is the radiation electrical field, and B is the radiation magnetic field. Substituting Equations (3)-(7) in Equations (1) and (2), and overlooking the small second order quantities, we get:

$$\frac{1}{c}\frac{\partial}{\partial t}E_0 = -\frac{4\pi}{c}(J_0 + \sigma_0 E_0) \tag{8}$$

$$\frac{1}{c}\frac{\partial}{\partial t}E_1 = \frac{2}{r}B - \frac{4\pi}{c}[\sigma_0 E_1 + \xi(J_0 + \sigma_0 E_0)] \tag{9}$$

$$\frac{1}{c}\frac{\partial}{\partial t}E_2 = -\frac{1}{r}\frac{\partial}{\partial r}(rB) - \frac{4\pi}{c}\sigma_0 E_2 \tag{10}$$

$$\frac{1}{c}\frac{\partial}{\partial t}B = -\frac{1}{r}\frac{\partial}{\partial r}(rE_2) - \frac{1}{r}E_1 \tag{11}$$

Equations (8)-(11) is the equation group which describes the nuclear explosion EMP. Equation (8) is an ordinary differential equation, and when giving the specific expression of Compton current J_0 and air conductivity σ_0, the analytic solution of radial field E_0 can be obtained. Equations (9)-(11) constitute

a group of quasilinear partial differential equations, and to find the unknowns E_1, E_2, and B, it is necessary to carry out numerical computations. The temporal relationship of the Compton current and the gamma-source can be approximated thus:

$$J_0(r,t) = -\phi(r,t)\frac{eL}{\lambda} \tag{12}$$

in which, $\phi(r,t)$ is the gamma-flux at point r, e is the electron charge constant, λ is the average free path of the gamma-photons, and L is the average range of the Compton electrons. The air conductivity σ_0 is determined by the charged electron density and their mobility:

$$\sigma_0(r,t) = e(\mu_\varepsilon n_\varepsilon + \mu_+ n_+ + \mu_- n_-) \tag{13}$$

in which μ_ε, μ_+, and μ_- are the mobility of the electrons, the positive ions and the negative ions, respectively, and they should be an electrical field function. Here the approximation is taken as a constant. n_ε, n_+, and n_- are the density of the electrons, the positive ions, and the negative ions, respectively, and they are solved by the air chemistry differential equations

$$\frac{dn_\varepsilon}{dt} = S(r,t) - \alpha n_\varepsilon - \alpha_\varepsilon n_\varepsilon n_+ \tag{14}$$

$$\frac{dn_+}{dt} = S(r,t) - \alpha_\varepsilon n_\varepsilon n_+ - \alpha_i n_+ n_- \tag{15}$$

$$\frac{dn_-}{dt} \alpha n_\varepsilon - \alpha_i n_+ n_- \tag{16}$$

In the equations, α is the coefficient of oxygen atom electron absorption, α_ε is the combined coefficient of electrons and positive ions, α_i is the combined coefficient of positive ions and negative ions. S(r,t) is the secondary source term which can be expressed:

$$S(r,t) = \phi(r,t)\frac{\nu}{\lambda} \tag{17}$$

in which ν is a number of secondary electrons produced by Compton electrons. In actual numerical computations, the temporal relationship of the gamma-source should use the actual gamma-time spectrum. First of all, the charged electron density is solved by the constant differential equations (14)-(16) to determine the boundary of the central plasma sphere and obtain the value of the air conductivity and Compton current, and then solve for the value of the radial field E_0 using Equation (8), and finally compute from Equations (9)-(11) E_1, E_2, and B and superimpose radial field E_0 and radiating electrical field E_2.

3. Radial Field

In order to get a simple image in discussion, some simplification can be carried out. We take into account the flight time of gamma-photons, and use the delay time T = t-r/c. And we let the gamma-source temporal relationship be:

$$\phi(r,T)=\begin{cases}\phi_0(r)\exp(aT) & 0<T\leqslant T_1\\ \phi_0(r)\exp(aT_1-bT) & T>T_1\end{cases} \tag{18}$$

In the equations, $\phi_0(r)$ expresses the gamma-flux at r of T=0 moment, T_1 is the moment gamma-flux reaches peak value. Substituting Equations (18) and (12) in Equation (8), and taking into account that the initial segment conduction current is much smaller than the Compton current, i.e., $J_0 \gg \sigma_0 E_0$, we have:

$$E_0(r,T)=4\pi\frac{eL}{\lambda a}\phi_0(r)[e^{aT}-1]$$

or
$$E_0(r,T)-E_0(r,0)=4\pi\frac{eL}{\lambda}\Phi(r,T) \tag{19}$$

Taking into account $E_0(r,0) \approx 0$, therefore we have:

$$E_0(r,T)=4\pi\frac{eL}{\lambda}\Phi(r,T) \tag{20}$$

In which $\Phi(r,T)$ is the gamma-integral flux or r location. From Equation (20) it can be seen that the growth of the initial segment of radial field is in direct proportion to the gamma-integral flux. When the electrical field enlarges and the conduction current increases with it to the point that it cannot be overlooked, E_0 departs from Equation (20), the growth rate of the electrical field gradually diminishes, and ultimately achieves the saturation value E_{0s}. This segment electrical field has the following form:

$$E_0(r,T)=E_{os}[1-\exp(-4\pi\sigma_0 T)] \tag{21}$$

Since σ_0 is a function of the distance r, with regard to the same moment, σ_0 diminishes as the distance increases. From the relationship of E_0 and σ_0 displayed in Equation (21) it can be seen that the closer the air is to the blast center, the earlier it achieves the saturation value. When the electrical field achieves saturation, i.e., $dE_0/dt = 0$, we can obtain the following from Equation (8):

$$E_{0s}=-\frac{J_0}{\sigma_0}=\frac{eL}{\lambda\sigma_0}\phi(r,T) \tag{22}$$

Since the mobility of the electrons is much higher than the mobility of the ions, the initial period of the explosion can approximate air conductivity only with the contribution of electrons, the constant differential equation group (14)-(16) is simplified to one differential equation and directly computed:

$$\sigma_0\approx\frac{e\nu\mu}{\lambda(a+\alpha)}\Phi(r,T) \tag{23}$$

substituting in Equation (22), we get:

$$E_{os}=L(a+\alpha)/\nu\mu \tag{24}$$

in which a is determined by the growth coefficient of the gamma-source, and the others are all parameters of the blast center environment. Equation (24) explains that the radial field saturation value is primarily derived from the blast center environmental parameters and is unrelated to the explosion equivalent. For low altitude nuclear explosions, the saturation value is 10^4 - 10^5V/m.

Drawing the relationship between the expressions of Equation (18) and Equations (21) together, as illustrated in Figure 1, one can see in general the temporal relationship of the radial field and the gamma-flux. The intensity of the initial period electron field rises in direct proportion to the gamma-flux, but then deviates gradually towards the saturation value. The time corresponding to the field intensity reaching the saturation value is E_{0S}, and at time T_S the gamma-flux is only ϕ_S. And the time corresponding to the gamma-flux peak is T_1.

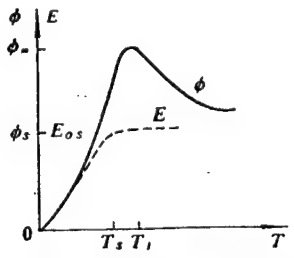

Figure 1. Curve of Temporal Changes of Radial Field and Source Field

Carrying out numerical computations based on the assumed gamma-spectrum under specified conditions, the curves at 150m of variations with time of Compton current J_0, conduction current $\sigma_0 E_0$, and radial field E_0 are as illustrated in Figure 2. It shows that in the initial stage, the growth of Compton current is far greater than the growth of conduction current, and at this time the radial velocity rises. Subsequently, the distance between the growth of the two currents becomes smaller. Beginning at 70 ns, the growth rate of the two almost tends to be uniform and at this time the radial field achieves the saturation value and then fluctuates slightly. The change in Compton current is in direct proportion to the changes in gamma rays. This indicates that change in the radial field is determined by the growth rate of Compton current and conduction current. The time that it reaches saturation value, is not the time that the gamma-source reaches peak value, but is the time Compton current and conduction current growth rates reach a balance.

Figure 3 provides curves of changes in the radial field at different distances. It can be seen that as the distance increases, the ascending leading edge of the radial field is slower and slower, the maximum value is smaller and smaller and the fluctuations in saturation value also gradually become smaller.

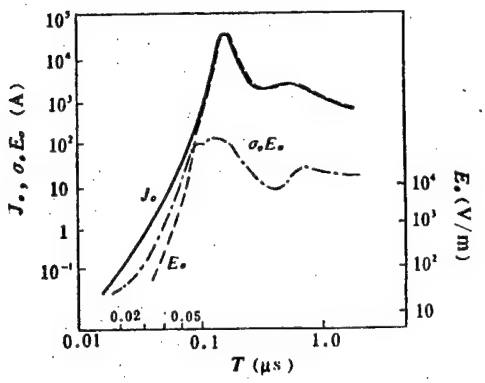

Figure 2. Change of J_0, σ_0, and E_0 at 150m With Time

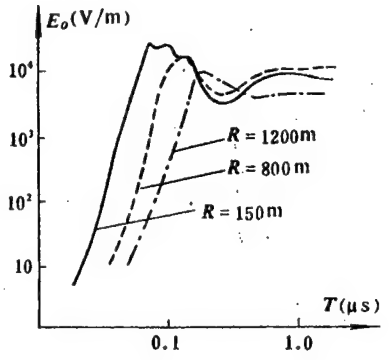

Figure 3. Radial Field Curves at Different Distances

The saturation phenomenon of electric fields is one of the characteristics of source region EMP, and the size of the saturation area can be expressed by the saturation radius R_m. Within the saturation area, the maximum field intensity formed by Compton current J_0 must be much larger than the saturation field value E_{0s}, and can be obtained from Equation (20):

$$4\pi \frac{eL\Phi(R_m, T_1)}{\lambda} \geqslant E_{0s} \tag{25}$$

i.e.,
$$\frac{\exp(-R_m/\lambda)}{R_m^2} N \frac{eL}{\lambda} \geqslant E_{0s} \tag{26}$$

or
$$R_m^2 \exp(R_m/\lambda) \leqslant eLN/\lambda E_{0s} \tag{27}$$

in which $N = \Phi(0, T_1)$ is the sum of the gamma-photons released from the start of the nuclear explosion to the peak time. From Equation (27) one can see that R_m increases slightly as N becomes larger, but is not extremely sensitive. For a nuclear explosion equivalent to 10 kilotons of TNT, the R_m is about 1 km, and for a megaton nuclear explosion, the R_m is 2-3 km.

4. Radiating Field

In addition to a radial field, in the source area there is also a radiating field. The waveforms (early part) computed at 300m for the central expansion electric dipole model adopted are illustrated in Figure 4. It can be seen that the initial part radiating field absolute value is far greater than the radial field value, thus the overlapping fields are primarily the contribution of radiating, and in the waveform manifest negativity. Subsequently, the radial field velocity rises, exceeds the radiating field value, and quickly reaches the saturation value.

If we consider the situation when the gamma-source is slowly increasing, then the initial section of the radiating field waveform will have an oscillating nature, as illustrated in Figure 5.

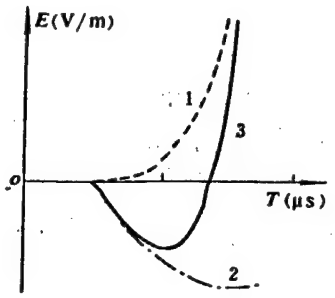

Figure 4. 1-Radial Field, 2-Radiating Field, 3-Source Region Overlapping Fields

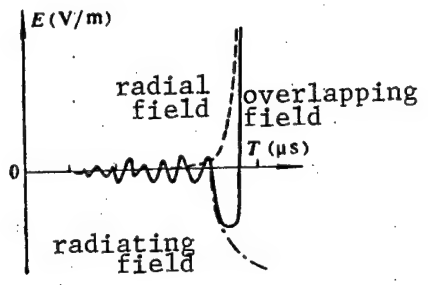

Figure 5. Computation Results of Early Source Region Signals When Gamma-Source Changes Slowly

The slightly later waveform is similar to the waveform illustrated in Figure 4. The field intensity of the oscillating part is between several mV/M and several hundred mV/m.

III. Primary Characteristics of Nuclear Vicinity EMP

On the basis of a discussion of the physical characteristics of EMP in the vicinity of a nuclear explosion, this section summarizes the test results and discusses the primary characteristics of plasma region, saturation field region, transitional region and radiating region with regard to EMP.

1. Blast Center Plasma Region

On-site measurements show that even close to the blast center a very strong electric field can be measured. This means that although the air near the blast center is under the irradiation of high intensity gamma rays, it is not completely ionized. Thus, in theoretical computations, treating the blast center approximately as an ideal conduction sphere is only a crude approximation.

2. Saturation Field Region

(1) Characteristics of Saturation Field Region Waveforms: The waveforms of the measurement source region saturation field of atom bomb explosions and hydrogen bomb explosions are as illustrated in Figure 6, in which E_{0S} represents the saturation field value. No matter whether it is an atom bomb explosion or a hydrogen bomb explosion, the saturation field is a forward pulse, the waveform exhibits a "flat top" and the field intensity is greater than 10^4V/m, unrelated to the explosion equivalent. The duration of the pulse "flat top" may reach more than 10μs. The ascending leading edge may be analogous to the gamma-source, but there are differences with the distance of the measurement point from the blast center. The waveforms illustrated in Figure 3 are equivalent to the initial part of Figure 6(a), the two are similar.

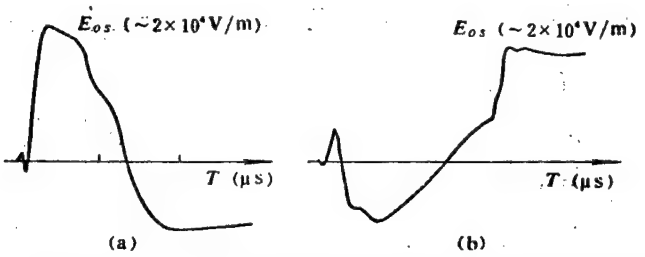

Figure 6. Diagram of Source Region EMP Measured Waveforms
(a) Atom Bomb explosion (b) Hydrogen Bomb Explosion

(2) Necessary Conditions for Forming a Saturation Field: A saturation field is an EMP phenomenon which appears in the special conditions of a nuclear explosion and it is subject to the limitations of time and space. According to Equation (2), when gamma-flux reaches the peak value Φ_m, the electric field formed by J_0 is written:

$$E_0(r,T_1)=eL\phi_m/\lambda a\varepsilon_0 \tag{28}$$

Here, we use the practical units system, $\varepsilon_0=\frac{1}{36\pi}\times10^{-9}(F/s)$, and if we take λ = 150m, L = 1.5m, a = 10^8/s, and take into account that Equation (28) must satisfy the condition $E(r,T_1)>>E_{0S}$, then

$$eL\phi_m/\lambda a\varepsilon_0\gg E_{os} \tag{29}$$

and if we take E_{0S} = 3.2 x 10^4V/m, then

$$\phi_m\gg1.7\times10^{22}(1/m^2\cdot s) \tag{30}$$

The above equation is the requirement of gamma-flux for forming a saturation field. Actual measurement results show that only when the gamma-flux reaches such a level will the radial field there be at saturation value. In addition to this condition, it also demands that the ascension rate of the gamma-pulse be fast enough. For the different types of nuclear explosion, the latter condition can always be satisfied, and the former condition can also be satisfied within a definite spatial scope. Therefore, a nuclear explosion can definitely establish a saturation field, only there are differences in the size of the saturation field region.

(3) Saturation Field Boundaries: At the time of a nuclear explosion, the saturation field's circumference can rapidly expand with time, the maximum radius it can achieve is determined by the nuclear explosion equivalent and environmental parameters (primarily air density), the saturation radius R_m can be estimated using Equation (27), under the practical units system it is:

$$R_m^2\exp(R_m/\lambda)\leqslant eLN/4\pi\lambda E_{os}\varepsilon_0=4.5\times10^{-16}N$$

For comparison, suppose a different equivalent is an explosion at the same altitude, the relationship of the saturation radius and the explosion equivalent is as illustrated in Table 1.

Table 1. Maximum Saturation Field Radius of Different Nuclear Explosion Equivalents

Nuclear explosion equivalent (kT)	1	10	10^2	10^3
Maximum radius of saturation field (km)	0.99	1.41	1.96	2.51

3. Transitional Region

Theoretically, the saturation field has a boundary, but it is very difficult to determine this boundary in actual experiments. On the one hand, the indefiniteness of the [explosion] equivalents and the environmental parameters directly affect the size of the anticipated saturation field region, and on the other hand, the electric field values near the boundary are constantly changing, but the waveforms outside the boundary do not have clear changes. However, as far as the shape of the waveforms of the transitional region, the waveforms of the region's radial field are as illustrated in Figure 7, they no longer have the characteristics of the saturation field but exhibit a forward pulse. The relationship of decay with distance is very rapid, similar to the case of gamma rays. At the same time, the characteristics of the radiating field are also clearly manifested. When the distance increases to a certain value (several km), the characteristic radial field forward pulse also no longer appears, and the waveforms measured are entirely radiating field signals.

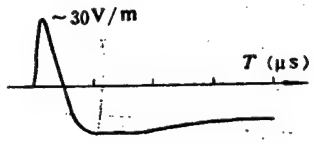

Figure 7. EMP Waveform of Atom Bomb Explosion Measured at 1.6 km

4. Radiating Field Region

In addition to the source region, within the range of nearly 100 km, the radiating field signals can also clearly reflect some characteristics of the nuclear explosion process. As the propagation distance increases, the high frequency portion decays very fast, these characteristics gradually disappear, therefore the radiating region of interest is the region within 100 km. Figure 8 gives the measured waveforms of several typical radiating fields. (a) and (b) are the results of measurements at 6.6 km and 35 km, respectively, from the same atom bomb explosion; (b) and (c) are the measurement results at roughly the same distance of two different explosion equivalents [(b) is kT level, (c) is MT level]. These typical waveforms show that:

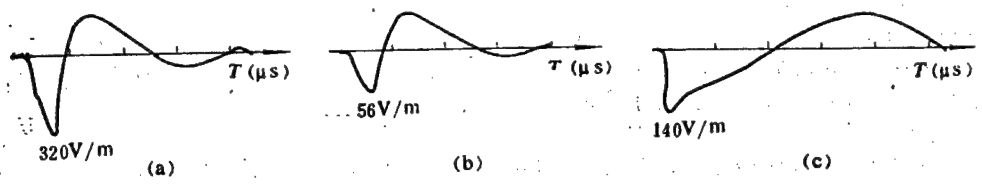

Figure 8. Diagram of Several Typical Observed Radiating Field Waveforms

(1) The EMP radiating signals of any atom bomb explosion are made up of three quasi half periods, the first half period being the negative pulse.

(2) For explosions at the same altitude, the peak value and the width of the radiating signal's first half period does not rely sensitively on the explosion equivalent. When the equivalent increases, there are slight increases in the peak value and the width.

(3) The decay of the radiating signal with distance is much slower than the radial field, approximating an inverse proportional relationship, and within 100 km, the waveforms do not generate obvious distortion, therefore radiating signals can be observed at very great distances.

(4) The asymmetry of the nuclear explosion environment severely influences the structure of the radiating signal. Changes in atmospheric density with altitude and the surface influences only affect the size of the signal and the detail of the waveform but cannot change the basic shape of the signal.

5. Frequency Spectrum of Nuclear Explosion EMP

Carrying out Fourier transformation of the EMP waveforms obtained, we can obtain its frequency spectrum distribution. Figure 9 is the frequency spectrum curve obtained from measurement, (a) was obtained from the source region field waveform and (b) was obtained from the radiating field waveform.

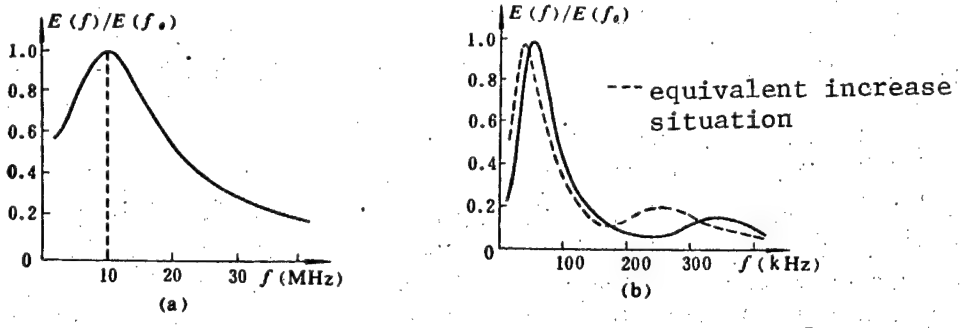

Figure 9. Analysis of Nuclear EMP Frequency Spectrum

The energy of the source region field is primarily concentrated in the 1-100 MHz band, its basic frequency being about 10 MHz. It should be pointed out that Figure 9A) only shows the frequency spectrum of the source region signal's

high frequency part, actually the low frequency part of the signal is rather large, this is because after the characteristic radial field pulse, a negative pulse of long duration and large magnitude appeared. Clearly, this pulse contained very high electromagnetic energy, its low frequency lower limit may be as low as several tens of Hz. For this reason, in terms of the entire source region EMP, the frequency element is rather rich.

The frequency spectrum of the radiating EMP signal is limited to a very narrow pass band below 500 kHz, the basic frequency range is between 20 kHz and 50 kHz, there is a definite relationship between its numerical value and the nuclear explosion equivalent: as the equivalent becomes larger, the basic frequency becomes lower. As the propagation distance increases, the high frequency element in the radiating signal gradually decays, becoming closer and closer to a lightning waveform. For hydrogen bomb explosions, the high frequency element of radiating signals within 100 km clearly increases. On the basis of this characteristic, the type of nuclear explosion can be distinguished over very long distances.

Here it would be explained that research on nuclear EMP is a topic which covers a very broad range, and the tests in this paper were based on the research results of many comrades over a long time. Here we would like to express our heartfelt gratitude to these comrades.

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APPLIED SCIENCES

CHINESE NUCLEAR DATA ACTIVITIES OUTLINED

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 3, Sep 85 pp 193-199

[Article by Li Shounan [2621 1108 8538], Institute of Atomic Energy, Beijing: "China's Progress in the Nuclear Data Field"]

[Text] Abstract. China has made great progress in the nuclear data field since the 1960's. The Nuclear Data Center was established in 1975. With the cooperation of personnel in nuclear physics and the relevant departments throughout the country, two stages of a nuclear data evaluation project have been completed, some important nuclear measurements have been made, efforts have been made to provide suitable experimentation and measurement capabilities, and the computerized "China Evaluated Nuclear Data Library, Edition 1" (CENDL-1) is nearing completion. This article describes China's progress in the nuclear data area and offers some suggestions for further work.

1. Introduction

Nuclear data are the basic information that is utilized in nuclear power production and is applied in nuclear technology. As nuclear science and nuclear power have developed worldwide, great importance has been attached to nuclear data activities; prolonged, major efforts have been made in nuclear measurements, theoretical calculations, and compilation and evaluation. Some of the leading countries in nuclear power have set up their own nuclear data organizations and data bases. The International Atomic Energy Agency's Nuclear Data Section [IAEA/NDS] is in charge of organizing international exchange and cooperation in the nuclear data field. This field is already a major area of international exchange and cooperation and an important measure of achievement in nuclear power applications.

Below we outline China's progress in the nuclear data area.

2. Establishment of the Chinese Nuclear Data Center

a. China gradually acquired a capability for experimental research in low-energy nuclear physics during the late 1950's and early 1960's. In the mid-1960's, in response to the development needs of the nuclear industry, Chinese nuclear physicists carried on a series of experimental projects to acquire data, performed various pressing tasks, established a certain experimental capability, mastered experimental techniques, and trained scientific and technical personnel, thus making a definite contribution to domestic work in neutron physics, fission physics, and the reactions of light nuclei.

b. During the 10 turbulent years, work was temporarily suspended. China's nuclear physics personnel gradually began a recovery in 1972-1973. In 1973, in the process of drafting an 8-year plan, the Institute of Atomic Energy drew up a specialized plan for nuclear data activities which set the militant objective of establishing China's own nuclear data system within 8 years or slightly longer [1]. Based on the needs of experimental nuclear physics and nuclear measurements, it put forward a plan for the modernization or reconstruction of accelerators [1] as white neutron sources for nuclear measurements and in addition called for the design and construction of a 100 meV high-current short-pulse linear electron accelerator [1]. In order to raise the standards of nuclear research and provide supplementary neutron sources in the 8-13 MeV range and higher, it was decided to import a 2 x 10 MeV cascaded electrostatic generator [1], and in order to meet the needs of theoretical calculations and the creation of nuclear data bases it was decided to import a computer capable of performing 1 million operations per second [1].

c. China's first nuclear data conference was convened in December 1973 for exchange of information on domestic nuclear measurements, international progress on nuclear data, and the nuclear data needs of China's nuclear power industry [2]. The conference led to a general recognition of the need for work in the nuclear data area and provided an important impetus for nuclear data activities.

d. In the spirit of this conference, the Institute of Atomic Energy established the nuclear data planning group at the beginning of 1974. Work began with a comprehensive survey of international nuclear data developments [3] and domestic needs [4] and an examination of nuclear data compilation and evaluation methods. In the measurement field, planning for a linear electron accelerator and a parallel static accelerator began in late 1973 and arrangements were made to measure $\bar{\upsilon}$ and σ_t for ^{239}Pu, the excitation curves for certain reactions, the gamma spectra and gamma ray production cross sections for neutron reactions, fission outputs, and the macroscopic characteristics of graphite.

e. The task of compiling and evaluating sets of neutron data was officially assigned in June 1975. The second nuclear data conference was held at the Institute of Atomic Energy in October 1975. The first stage evaluation project was organized and carried out and a 10-year plan for nuclear data activities was drafted [5]. The construction of the Ministry of the Nuclear

Industry's Nuclear Data Center was formally announced, a national nuclear data cooperation network was established, and nuclear data compilation and evaluation methods and the suitability of existing nuclear theoretical models for the computation of nuclear data were examined. After the Second Nuclear Data Conference, China's nuclear data activities entered a new stage.

3. Nuclear Data Activities After the Establishment of the Nuclear Data Center

3.1. Completion of Two Stages of the Nuclear Data Evaluation Project

Since the Second Nuclear Data Conference China has carried out two stages of a nuclear data evaluation project, which were examined and approved at the Third and Fourth Nuclear Data Conferences.

a. The task of the first stage was to provide evaluated and recommended data meeting 1970's standards, chiefly sets of neutron data on 16 nuclides. The first task was effectively completed in 1978 as a result of 2 and 1/2 years' work, providing sets of evaluated and recommended data on all fast neutron reaction paths for 16 radionuclides, including H, D, T, ^{6}Li, ^{7}Li, Al, Fe, ^{235}U, ^{238}U, and ^{239}Pu [7], and evaluated and recommended data on the yields of 33 nuclear reaction products from fission-spectrum neutrons and certain monoenergetic neutrons [3]. In addition, the excitation curves for 30 neutron reactions were measured and evaluated, and data were compiled, evaluated and recommended for the decay diagrams of 100 nuclides.

The cutoff point for recommended data was 1976. Our compilation included new data published after the completion of similar foreign works and ENDF/B-IV [Evaluated Nuclear Data File]. In general, owing to our analysis of the literature on experimental measurements and comparison of foreign evaluated data, our recommended data are rather reliable. The theoretical calculations were generally based on mature models. We conscientiously adjusted the relevant parameters and made system studies, with the result that most of the calculations agreed with experimental data and the figures were comparable in quality to international values obtained at that time by the same types of calculations.

b. The second stage of the project, completed in 1983, involved the following work:

Sets of data on all fast neutron reaction pathways for 21 nuclides including ^{10}B, ^{11}B, C, O, ^{23}Na, Mg, Si, V, Cr, Ni, Cu, Zn, Zr, No, Mb, Sn, Hf, Ta and Au were evaluated and recommended. The 37 sets of neutron data from the two stages of the project were stored in computer memory in the ENDF/B format (on tape) and the equivalents of the ENDF/B-IV files 1, 3, 4, and 5 were provisionally set up.

In order to expand the range of energies to the thermal region and to make preparations for files 2 and 7, we evaluated the resonance parameters for about 90 nuclides [8], evaluated the data on the scattering laws for thermal neutrons and investigated theoretical calculations. Thermal neutron-induced

gamma ray output data for 75 nuclides and fast-neutron gamma ray output data for 27 nuclides were compiled and evaluated.

The decay data for about 257 commonly used nuclides were revised and evaluated [10].

Yield data on thermal neutrons and fast reactor spectrum neutrons for 22 fissionable isotopes including U and Pu and more than 200 fission products produced by monoenergetic neutron induction were revised [9].

Excitation curves for neutron-nucleus reactions of 30 isotopes [11] and excitation curves for charged particle-nucleus reactions of 18 isotopes were revised [12] and the excitation curves for 58 neutron-nucleus reactions were calculated from theory.

In addition, initial calculations were made of nonelastic discrete energy level cross sections, angular distributions and secondary neutron spectra for uranium and plutonium isotopes. Various data on transplutonium nuclides, reaction cross sections for reactions between charged particles and light nuclei, absolute delayed neutron yields, photonuclear reactions and photofission as well as standard data were compiled and evaluated.

The evaluated and recommended nuclear data from the second stage of the project were of good quality. The experimental data were taken from EXFOR 80-81, obtained from IAEA/NDS, and were supplemented from the 1982 CINDA [Computer Index of Neutron Data] and the most recent data from journals. As a result, our data included 1973-1981 experimental figures not available in ENDF/B-IV. Some of the data were from our own theoretical calculations; in the theoretical calculations the parameters were adjusted carefully, and most of the results agreed with experimental data. Some of the data were supplemented from ENDF/B-IV and INDL/V. These data have already been entered in the data base as needed and are available for use.

3.2. Establishment of Computerized Data Bases

The use of computers for nuclear data evaluation and the establishment of nuclear data bases began in 1980. In 1983 the data center installed a PDP 11/70 computer system for the nuclear data base and for evaluation; both evaluation and data base creation have gradually been transferred to this system. The main work done prior to 1984 included the following:

a. A nuclear experimental data base. The retrieval program was set up on an ACOS-500 machine and the experimental data in the EXFOR data format obtained from IAEA by exchange has already been made available for use.

b. An evaluated nuclear data base. The management program system was established on a FELIX-C512 machine, and the sets of neutron data for 37 nuclides obtained during the first two project stages have already been included in the data base, stored on tape in the ENDF/B format. The computerized China Evaluated Nuclear Data Library, First Edition (CENDL-I) is nearing completion [13].

c. An interactive computerized nuclear data evaluation system was developed and set up on an ACOS-500 machine and has been used in evaluating neutron data for 21 nuclides.

d. A resonance parameter testing system has been provisionally installed on the PDP 11/70 machine.

Thus the computerized nuclear data base is already in a fledgling state; the computers are being used for nuclear data evaluation, nuclear data tapes are being used for international exchange, so that a preliminary capability for meeting domestic needs is now in place.

3.3. Generation of Group Constants and Macroscopic Testing of Nuclear Data

In order to meet the urgent needs of reactor engineering, the nuclear data center has organized the relevant units for joint compilation of a set of micro-scale data for 30 nuclei commonly used in reactor engineering [14] and has used the data to generate group constants for 9 elements for reactor use [15].

The Beijing Institute of Applied Physics and Computational Mathematics has set up a preliminary neutron group constant processing system (NGCPS) [16] and has used the evaluated nuclear data from the first stage of the project to generate group constants and test them.

The data center, in cooperation with other units, has established a thermal reactor group constant program (RQCS) [17], has produced 68 group constants for 54 groups of 9 nuclei as well as 25 group constants for shielding, and has established a fast group constant production program (KQCS) [18].

In the area of macroscopic testing, a one-dimensional discrete-coordinate anisotropic scattering SN program (DSNF) has been created and a Carlson SN program for scattering [19] have been installed and used to test evaluated data for ^{235}U, ^{238}U, ^{239}Pu, Fe and Na. A one-dimensional diffusion program (NDP) [20] and a two-dimensional diffusion burnup program (TDBDC) [21] have been installed; their computation results have agreed well with 14 U.S. reference test results.

The Southwest Nuclear Physics and Chemistry Research Institute has established a reference device for testing depleted uranium pellets and has performed macro-scale experiments on D-D neutrons, 14 MeV neutrons, and ^{252}Cf neutrons with it; the device is already being used to test the first stage nuclear data, measurement results are now being obtained [22].

The Institute of Atomic Energy has also established an isotropic reference fast neutron field in a swimming pool reactor thermal column [23]. This work has given us an initial nuclear data testing capability and has provided certain capabilities for further testing of CENDL-1.

3.4. Theoretical Calculation of Nuclear Data

The theoretical calculation of nuclear data has an important role in the evaluation process. Such data as σ_f, σ_t, low-energy $\sigma_{n\cdot r}$, ν [nu] and the like can largely be provided from experimental data supplemented by theoretical calculations, but other data such as energy spectrum angular distributions and (n, 2n) and (n, 3n) data and the like must largely be obtained by calculation.

In the first stage of the project mature international modeling theories and methods were used to calculate nuclear data. These data are brought together in the book "He Fanying Lilun Fangfa Ji Qi Yingyong Wenxuan" [Collected Papers on Theoretical Methods in Nuclear Reactions and Their Applications] [24]. The theoretical framework for nuclear data that was established during the first stage of the project focused primarily on standardization and format unification of computation programs for medium and heavy nuclei. Nankai University undertook the task of compiling the Unified Data Computation Program for Medium and Heavy Nuclei [25], which combined the optical model, the H-F statistical theory, the evaporation model and the exciton model; with the cooperation of the data center and Wuhan University it has been completed and put into use. Because of the advances in nuclear data work, good progress has already been made in such basic research areas in nuclear theory as microscopic optical potentials, fission mechanisms, three-body reactions, and radiative capture. The two-exciton cross section theory developed by us, which uses exciton model calculations, is already usable for nuclear data calculations [16] and has been used internationally.

3.5. Improvement of Nuclear Measurement Capabilities and Progress in Measurements

a. Since 1973 the Institute of Atomic Energy has used existing capabilities to make certain nuclear measurements such as the value of $\bar{\nu}$ for ^{239}Pu and ^{252}Cf and the value of σ_f for ^{239}Pu, attaining rather high precision [27-29]. By combining the measurement, compilation and evaluation of excitation curves for neutron-nucleus reactions, a set of rather high-quality evaluated data has been recommended [30]. The absolute yield figures for ^{99}Mo in fission of ^{235}U initiated by thermal neutrons and fission-spectrum neutrons still contain some disagreements [31]. Secondary neutron energy spectra and angular distribution data for certain nuclei with 14 MeV, 11.6 MeV and 8.6 MeV neutron have been measured [32]. The (n, n'γ) reaction cross sections and gamma spectra for the elements C, F, Mg, Al, Si, Cu, Ni, Pb and Bi for 14 MeV neutrons have been measured [33].

b. Sichuan University's Institute of Nuclear Science and Technology used a nanosecond-pulse modulation high-voltage multiplier and a static accelerator to measure neutron elastic scattering cross sections and angular distributions. Jilin University and the Institute of Atomic Energy used a Ge (Li) gamma spectrometer to measure decay diagram data for certain nuclei. Qinghua University has performed research on small-angle neutron scattering. Beijing University has measured inelastic scattering cross sections.

c. The Institute of Atomic Energy's HI-13 parallel static accelerator is likely to begin operation in 1985. A special neutron chamber has been established for nuclear measurements; it is equipped with a neutron time-of-flight recorder, a general-purpose neutron target chamber, a gamma ray angular distribution meter and a fission target chamber.

When the parallel accelerator is completed, it will provide a good pulsed neutron source. It will then be possible to measure angular distributions and energy spectra for neutron scattering, wide-energy-range (n, 2n) and (n, 3n) cross sections and the like, which will be extremely important in supplying missing data for the 8-13 MeV range.

3.6. International Exchange and Cooperation

International exchange and cooperation in the nuclear data area have gradually expanded since 1978. Chairman of the Japan Nuclear Data Commission and Chairman of the Physics Division of the Japan Atomic Energy Institute K. Tsukada, Deputy Director of the U.S. national data center S. Pearlstein, Dr K. Okamoto of the International Atomic Energy Agency's Nuclear Data Section, and Chairman of the U.S. Oak Ridge RSIC B.F. Maskewitz have visited China to lecture and to study exchange and cooperation.

The Institute of Atomic Energy has sent personnel to Japan to investigate nuclear data work there, as well as to an international nuclear data conference in Antwerp and to the Geel and Harwell laboratories.

As a result of these activities we have established preliminary exchange and cooperation ties and have obtained valuable international experience and some valuable data. In addition we have set up a cooperative nuclear data evaluation system with the United States National Nuclear Data Center (NNDC), we have signed an agreement for data evaluation studies on transplutonium nuclei with IAEA/NDS, and we have investigated cooperation in fission yield evaluation and data base creation.

In 1983 China joined the IAEA and the Ministry of the Nuclear Industry's Nuclear Data Center was officially named the "China Nuclear Data Center." In 1984 China sent observers to the 10th International Nuclear Data Committee session and was received as a regular member of the committee; thus our nuclear data activities and international exchange and cooperation relationships entered a new stage.

4. Further Development of Nuclear Data Activities

Chief among China's future tasks in the nuclear data field are increased completeness and improved quality.

a. We must make CENDL-1 more complete and upgrade it. We need to complete a collection of neutron reaction data equivalent to files 1-7 of the ENDF/B data base, suitably expand the complete neutron data sets for certain nuclei in order to expand their usability, and strive to supplement the neutron-gamma production data in files Nos 12-16 and covariance file 33. This requires the following:

(1) In the area of theoretical calculations, we must improve the unified fast-neutron data calculation program for medium and heavy nuclei, e.g., by allowing for multiparticle emission processes, direct interaction and the deformed-nucleus optical model. We must then proceed to establish a multi-function unified standard program and focus on investigating and establishing theoretical methods and programs for calculating data for 19 light nuclei and gamma production data (including cross sections and energy spectra). We must gradually establish standardized program libraries for theoretical calculations.

(2) We must rewrite the nuclear data evaluation program, the experimental data base and the evaluation data base on the PDP 11/70 computer, as well as the relevant management program system. We should improve the international compatibility of the data base.

(3) We must establish a group constant program for reactor use, connected with the nuclear data base, and use CENDL-1 to generate group constants for practical use.

b. We must focus on experimental research on microscopic data, use the cascaded electrostatic generator to perform nuclear measurements, particularly in the 8-13 MeV neutron energy range, speed up the building of high-current short-pulse linear electron accelerators, and designate certain high-voltage multipliers for conversion into nanosecond-pulse modulators.

We must use the multipliers, electrostatic accelerators and cyclic accelerators to obtain data that is lacking and important nuclear data on which there is disagreement, as well as absolute measurements for single-energy points. We must strive to increase measurement precision.

We must continue measuring ^{235}U fission yields for fission-spectrum neutrons and clear up disagreements.

The data center must draw on its evaluation activities to suggest specific measurement tasks so as to make full use of existing capabilities and develop measurement activities.

c. We should intensify macroscopic experimentation and nuclear data testing; the data center should set up computer programs linking the CENDL-1 data base and the group constant production programs as rapidly as possible, as well as programs linking the group constant programs and programs for calculating integral quantities; and we must use reference experimental data to test the CENDL-1 data. We must make a vigorous effort in the evaluation of reference testing, make thorough use of reference devices and conduct integral experiments.

d. We must actively participate in all of the IAEA Nuclear Data Section's organizations and all specialized activities arranged by it, intensify cooperation with other nuclear data centers, intensify publications activity, suitably organize our personnel, and expand certain areas, such as radiation damage data for fusion reactor materials and atomic-molecular data. We must

thoroughly utilize favorable international conditions to speed up the upgrading of China's nuclear data standards.

e. We must establish a China nuclear data committee as soon as possible to modernize and strengthen guidance of our nuclear data activities.

International nuclear data activities have been broadening and deepening, and their range of application is constantly expanding. Nuclear data bases require timely updating; China's nuclear data activity must include systematic research and long-term planning, and work in important areas must gradually be deepened.

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8480/6091
CSO: 4008/13

APPLIED SCIENCES

NUCLEAR TRACK CODE TECHNIQUES

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 4, Jul 85 p 62

[Article by Meng Wu [1322 2976], Institute of Atomic Energy, Chinese Academy of Sciences: "Nuclear Track Code Technique"]

[Text] Many measures are used to prevent forgery but these methods all can be copied. Can we find a marker method which cannot be reproduced? This aim can be achieved by using fixed track technology. This method has important significance for making classified documents, printing revalued currency, authenticating objets d'art and safeguarding the prestige of brand name goods.

1. Principles: A fixed track is an etched pit which appears in a microscopic field after a track produced by charged particles in a dielectric solid is chemically etched. Using these etched pits (i.e., tracks) one can create many forms and types of nuclear security codes. In terms of their nature, they can be divided into two kinds: dark codes and light codes. The dark codes can be either colored or colorless by use of a developer. Below we combine a description of several practical applications with their principles.

(1) Position marker method: a mark is placed in a certain position on papers using the colorless developer or several characters can be written using the color developer, papers treated in this way can be distinguished from forgeries, and when it is necessary to tell them apart, using a fixed track detector plate at the location of the mark, radiate it in a thermal-neutron field for 20 seconds, then remove the detector and after etching, observe it under a microscope to distinguish true from false papers.

(2) Content marker method: Although in the above method three place numbers can be used to make up thousands of papers which can be distinguished from each other, it is easy to break the code. But the content method does the marking using a special content discharger, so that not only does the position of the mark change, but the content changes as well, and this makes it very difficult to copy.

(3) Statistical marker method: We know that nuclear events have a statistical nature, that is, using the same source and target, there could never be the same track distribution, and utilizing this quality, we can make a nuclear code which cannot be copied.

2. Experimental results and discussion: Experiments have been made on all three of the above described methods and the results show that they are feasible.

The nuclear track code technology introduced in this paper actually uses charged particle tracks to form numerals, symbols, pictures, and characters. It is different from ordinary security code microscopic dots. After being developed chemically ordinary security code microscopic dots can be appropriately magnified and reproduced or altered but nuclear tracks are damage tracks of charged particles in a solid state, and their form is extremely difficult to reproduce.

8226/8309
CSO: 4008/37

APPLIED SCIENCES

PROGRESS IN ION-BEAM FUSION RESEARCH REVIEWED

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 3, Sep 85 pp 269-276

[Article by Wang Naiyan [3769 0035 1750], Institute of Atomic Energy, Beijing: "Progress in Ion Beam Inertial Confinement Fusion Research"]

[Text] Progress in particle beam fusion research and key problems still awaiting solution are outlined. A light-ion beam is a potentially ideal driver for inertial-confinement fusion because the pulsed power source for producing light ions is cheap and highly efficient. Research on diodes capable of efficiently producing a high-brightness ion beam is described. The stopping power for light-ion beams has been calculated, taking account of both electrons confined in the target and free electrons. Experimental results show that when the current density of the beam is relatively high, the stopping power is twice that for a cold target. Implosion research is under way and cylinder implosion experiments have been performed.

Research on fusion by inertial confinement with a light-ion beam began in the 1970's and has developed rather rapidly; it is now being vigorously pursued in such countries as the United States and Japan. The main reason for the hopes reposed in light-ion beam fusion is that such beams can be produced with high efficiency. The efficiency of the conversion from electric power to ion beam power may be as great as about 30 percent and the energy deposition behavior in the target is highly satisfactory: the range is short and the maximum energy deposition per unit path length occurs near the end of the trajectory, so that when an ion beam strikes a target there is no problem of preheating of the central thermonuclear fuel; in addition, compression of the time interval which a nonrelativistic ion beam takes to cover its flight distance increases the power density of the beam. But there are many problems in achieving burn, primarily involving ion beam transmission and focusing, so that for the near term, efforts are focusing primarily on pulse power compression, increasing beam brightness and decreasing beam divergence so as to increase the irradiation power density per unit area of target. Below we discuss progress in international ion-beam fusion research and the main problems involved.

1. Beam Requirements for Ion-Beam Inertial Confinement Fusion

According to theoretical calculations, in order to attain the break-even condition, the ion beam energy deposition in the ablation layer must be 1×10^7 J/g; the speed with which the layer is propelled and the thermonuclear fuel is compressed must be 2×10^7 cm/sec. Specifically, for a target pellet with a radius of 1 mm, the total energy of the particle beam must be in the megajoule range, the beam power must be about 100 TW, and the power density at the target must be about 10^{14} W/cm^2.

With 36 target impact paths, the power density at the target is related to the beam power density D as follows:

$$P = B \cdot K \cdot \delta \tag{1}$$

where B is defined as

$$B = \frac{\text{beam power density}}{\text{vertical microscopic divergence X horizontal microscopic divergence}}$$

For convenience of discussion we assume that the vertical and horizontal microscopic divergence angles are both equal to $\Delta\theta$, with $\Delta\theta \sim \frac{r}{D}$, where r is the radius of the target and D is the distance between the beam source and the center of the target; accordingly the solid angle $\Delta\delta$ which the ion emission source subtends at the target center satisfies the condition

$$\Delta\delta = \frac{S}{4\pi r^2} = \frac{S_0}{4\pi D}$$

where S_0 is the surface area of the emission source and S is the irradiated surface area of the target.

The beam power per unit area on the irradiated target is $\frac{S_0 JV}{S} = \frac{JV}{(\Delta\theta)^2}$, where J is the ion beam intensity and V is the ion energy. $\frac{IV}{(\Delta\theta)^2}$ is called the beam brightness; its physical meaning is the beam power incident on a unit area of the target. Obviously, in order to achieve burn the beam brightness must be 10^{14} W/cm^2·sr or more.

Experiments have shown that a foil converging reflector diode has a current density of 3-30 kA/cm^2 [1], while with an impressed magnetic field diode the current density is between 7 and 35 kA/cm^2 [2]. Even in those ranges the beam divergence was independent of the current density, so that large current densities help increase beam brightness and the two quantities are essentially in a square relationship. The calibration relationship between the beam brightness and the voltage is attracting the most attention, because increasing the voltage V also decreases $\Delta\theta$, and it has been demonstrated with the limited data currently available that the beam brightness is proportional to V^2 [3] (see Figure 1). With a 1.8 MeV proton current the same brightness

is 10^{13} W/cm^2-rad^2, still an order of magnitude below the burn requirement, so that burn can be achieved by increasing the voltage and decreasing the divergence.

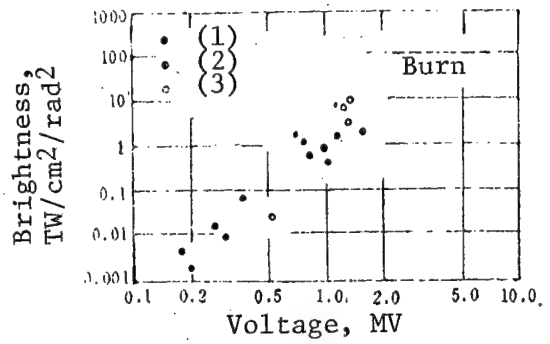

Figure 1. Calibration Plot of Beam Brightness vs. Voltage for Three Diode Types

Key:
1. Applied magnetic field
2. Automatic injection magnetized plasma
3. Foil condensing reflector

The beam divergence angle $\Delta\theta$ is determined chiefly by the following factors:

a. Polarization of the ion beam in a non-magnetically-neutral zone. When designing the ion beam diode, every effort must be made to decrease the non-neutralized magnetic field in the ion current transmission area and to decrease the length of the path through a nonneutralized region that the ions must travel, which is equivalent to decreasing the transit time. Accordingly, increasing the voltage to increase ion energy and using ions with large mass will decrease the effect of the nonneutralized region on the directional deviation of ion motion, and thus it is advisable to use ions with a small charge-to-mass ratio.

b. The filamentary instability that occurs in the ion beam in the acceleration gap partly changes the space charge distribution and produces angular and radial electric fields, thus increasing the divergence angle.

c. Instabilities produced by interaction with the cathode plasma when the ion beam passes through the electron cloud, and the effect of intrinsic gas scattering on the divergence angle.

d. The effect of nonuniformities in the anode plasma.

Summarizing the above, the light-ion beam driver must have the following characteristics: 1) large accelerating voltage; 2) high beam density; 3) large deflecting magnetic field; 4) magnetically neutral beam transmission; 5) medium-mass ion beam.

2. Research on Ion Beam Diodes

In order to develop diodes suitable for burn requirements, the main focus worldwide is on three types of ion beam diodes, namely the foil condensing reflector diode, the impressed magnetic field diode and the automatic injection magnetized plasma diode. The last-mentioned of these types is being developed most rapidly. The design and operating principles of this diode are shown in Figure 2.

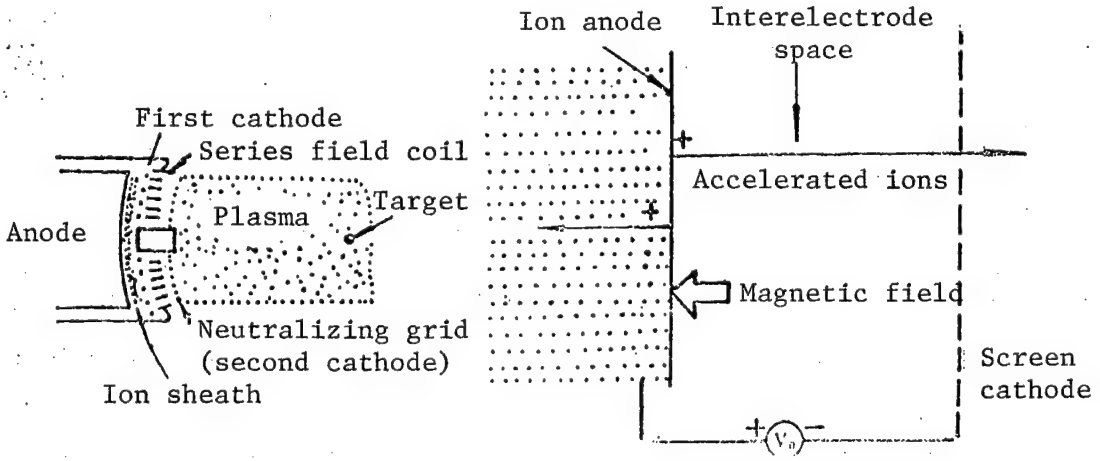

Figure 2

A plasma is first injected into the gap between the anode and cathode; the ions are pulled out of the plasma. The anode is in direct contact with the plasma, while the cathode has a triple grid structure: the first cathode, the series field coil and the second cathode. The series field coil is located between the cathode and anode; a current flowing through this coil produces a magnetic field component parallel to the electrodes, so that a magnetic potential is applied to the anode plasma, which moves it to the left, producing an acceleration gap whose size increases over time. As a result, the resistance and voltage of the diode also increase over time, which has the effect of focusing the beam. After the ion beam passes through the field coil and reaches the second cathode, it acquires electrons from the plasma in the drift area, so that the beam is neutralized; for this reason, the second cathode is often called the "neutralizing cathode." Because the magnetic field increases in pulsed fashion over a short time interval, it cannot penetrate the drift area, so that the transmission in the drift area is beam neutralizing transmission. In addition, this diode has the ability to select the ions that are accelerated; it accelerates only ions with a small charge-to-mass ratio [4]. Experimental results [4] indicate that the ion beam divergence is small and the focusing is good (see Table 1).

The divergence for Li^{2+} ions is smaller than that for H^+ ions, indicating the benefits of selecting ions with a small charge-to-mass ratio. But the mismatch between the anode plasma production time and the voltage waveform time

is much greater for Li^{2+} than for H^+, which hinders an increase in beam power. Accordingly the problem of producing a large-area spatially uniform plasma of suitable density and high purity that forms in the early part of the diode voltage pulse is critical to the quality of a high-current ion beam.

Table 1. Experimentally Obtained Emission Angles and Beam Brightnesses

	Horizontal divergence, mrad	Vertical divergence, mrad	Beam brightness, TW/cm^2-rad
Hydramite automatic injection magnetization plasma mixing diode (Li^{2+})	10	10	2
PBFA-1 automatic injection magnetization plasma mixing diode (H^+)	25	27	1

3. Investigation of Ion Beam-Target Interaction

At low beam densities the beam's energy deposition in the target follows the classical laws. At high beam densities, because the degree of ionization in the target is high and the number of free electrons in it is accordingly increased, the target's ion stopping power will be higher than for a low beam density. Experiments have verified that the increase may be as great as a factor of 2. This intensification effect is still in accordance with the classical laws, but allowance must be made for the stopping power of the electrons. Because of the increased energy deposition, the requirements regarding beam density can be relaxed (at the time of burn).

The Naval Research Laboratory has used a foil condensing reflector diode in the Gamble-II accelerator to produce 1.2 MeV deuterium ions that strike a 6.4-μm Mylar film and a 6-μm aluminum film, to the front and back of which 0.3 μm and 1 μm CD_2 plates are bonded to measure the deuterium ion energy at the front and back of the target (see Figure 3). The neutron time of flight method is used to detect the neutrons from the D-D reaction, making it possible to calculate the deuterium's energy and determine its energy loss in the target [5]; the experimental results are shown in Figure 4.

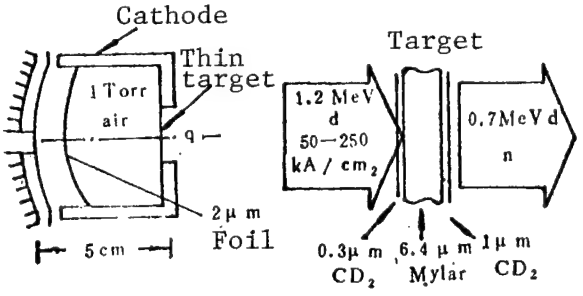

Figure 3

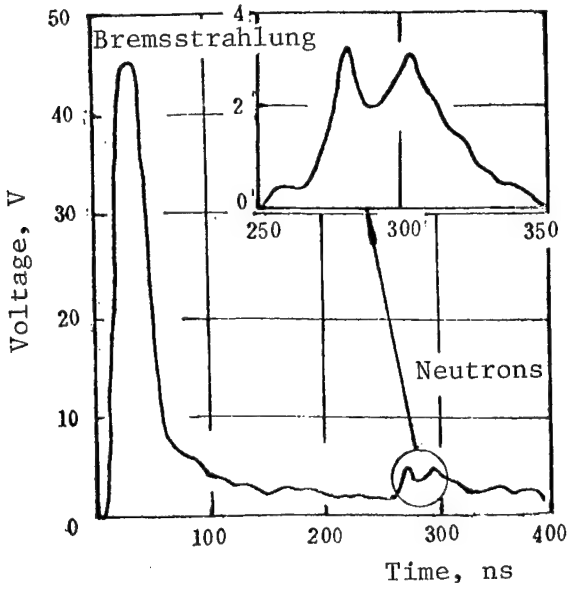

Figure 4

The target temperature is measured with an X-ray diode and the Saha equation is then used to calculate the degree of ionization of the target, which makes it possible to calculate separately the stopping powers of bound electrons and free electrons:

for bound electrons, $$\left(\frac{1}{\rho}\frac{dE}{dx}\right)_b \doteq 143 \frac{A_1 Z_1^2 Z_2}{E A_2} \ln(\Lambda_b)$$

for free electrons, $$\left(\frac{1}{\rho}\frac{dE}{dx}\right)_f \doteq 143 \frac{A_1 Z_1^2 Z_2}{E A_2} \ln(\Lambda_f)$$

$$\Lambda_b = 109 \frac{E}{A_1 Z_2^{0.82}}, \qquad \Lambda_f \doteq 59 E A_2^{\frac{1}{2}} / [A_1 (\rho \bar{Z}_2)^{\frac{1}{2}}]$$

$$\bar{I} = 2 \times 10^{-6} Z_2^{0.82}$$

where A_1 and Z_1 are the atomic weight and atomic number of the ions incident on the target and A_2 is the atomic weight of the target atoms. The target's total stopping power for the ions is

$$\left(\frac{1}{\rho}\frac{dE}{dt}\right)_t \doteq 143 \frac{A_1 Z_1^2 Z_2}{E A_2} \left[\frac{Z_2 - \bar{Z}_2}{Z_2} \ln(\bar{\Lambda}_b) + \frac{\bar{Z}_2}{Z_2} \ln(\Lambda_f)\right]$$

$$\bar{\Lambda}_b = [(Z_2 - \bar{Z}_2)/Z_2^{1.18}] \Lambda_b$$

the average ionization potential is

$$\tilde{I}(\bar{Z}) \doteq [Z/(Z-\bar{Z})]^2 \tilde{I}(Z-\bar{Z})$$

the path length in a cold target is

$$R_C \doteq 5 \times 10^3 \frac{A_2 E^2}{A_1 Z_1^2 Z_2 \ln(\Lambda_b)}$$

while in a highly ionized target material it is

$$R_A \doteq 5 \times 10^{-3} \frac{A_2 E^2}{A_1 Z_1^2 Z_2 \ln(\Lambda_f)}$$

Theoretical calculations indicate that for highly ionized target materials with low values of Z, such as H^{+1} (energy 3 MeV), He^{+1} (12 MeV), Li^{+2} (26 MeV) and C^{+4} (62 MeV), the range is 10 mg/cm^2. Given the requirement that a unit mass (in grams) on the target surface must absorb 10^7 J of beam energy, and assuming an ion beam width of 10^{-8} sec, the beam intensities incident on a unit target area needed to achieve the break-even condition are shown in Table 2.

Table 2. Beam Intensity on Target for Break-Even Condition

Characteristic	Type of ion			
	H^{+1}	He^{+1}	Li^{+2}	C^{+4}
Energy, MeV	3	12	26	64
Accelerating voltage, MV	3	12	13	~16
Beam intensity at target, kA/cm^2	3.3×10^3	8.3×10^2	3.9×10^2	1.6×10^2

4. Investigation of the Ion Beam-Driven Fusion Process

The experimental implosion layout is shown in Figure 5 [6, 7]. The proton beam peak energy is 1.5 MW, the peak current is 360 kA and the target temperature achieved is about 7 eV (peak). To allow small-aperture photography, a conical target is used. A small-aperture photograph is shown in Figure 5 (left). A cylindrical target is used in actual implosion experiments; four ruby laser holographic interferometers are used to measure the speed of the cylindrical target when irradiated by the ion beam: a slit photograph of the position of the imploding cylinder's interior surface is taken every 11 nsec, making it possible to determine the speed of movement of the interior surface. The results are shown in Figure 6 [3]. M.M. Widner and S.L. Thompson used the

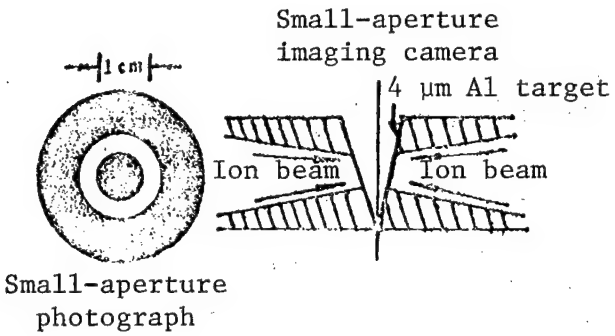

Figure 5. Experimental Layout for Ion Beam Impact on Target

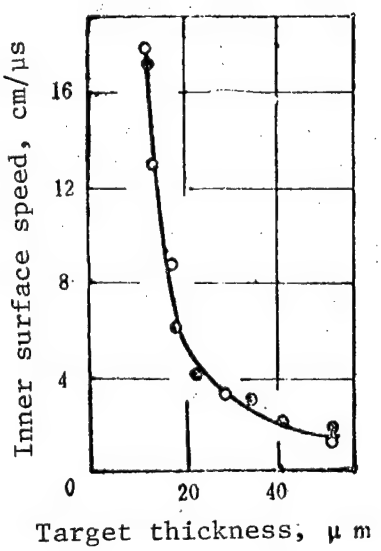

Figure 6. Measured Rear Surface Speeds

Proton flux power density on target 0.56 TW/cm^2
Al cylinder 6 mm in diameter
Dark circles indicate holographic measurement results
Light circles indicate calculated values from fluid mechanics program
Proton path length in target 15 μm

CHARTD program [9] to calculate a rear surface speed of $v = 4.5 \times 10^6 \ln \left|\frac{T}{T-15}\right|$ (where T is the thickness of the target in μm); this is called the "rocket model." The calculation results agree very well with the experimental figures; naturally T must be greater than the range R. Experiments have shown that for targets of the same thickness, v is proportional to $I^{0.5}$, i.e., the greater the incident ion flux, the faster the rear surface speed v. Using the one-dimensional fluid-mechanical equation and the continuity equation

$$\begin{cases} m_i n \left(\frac{\partial}{\partial t} + v \frac{\partial}{\partial z}\right) v = -KT \frac{\partial n}{\partial z} \\ \frac{\partial n}{\partial t} + \frac{\partial (nv)}{\partial z} = 0 \end{cases}$$

we obtain

$$v(t) = v_{ia} \ln \left[\frac{m_0}{m(t)}\right], \quad v_{ia} = \sqrt{\frac{2KT}{m_i}}$$

$$m(t) = m_0 - t\frac{dm}{dt}$$

Thus v(t) changes over time, increasing as the implosion process develops. The rear surface velocity plotted in Figure 6 is for the time at which the rear surface has moved to half the central distance.

The kinetic energy of the rear surface is

$$\frac{1}{2} m(t) v^2(t) = \frac{1}{2} m(t) v_{ia}^2 \left\{\ln \left[m_0/m(t)\right]\right\}^2$$

The proportion of the incident ion beam energy that is converted to kinetic energy of the moving layer is

$$\frac{m(t)v^2(t)}{2E_p} = \frac{1}{8} \frac{m(t)}{m_0 - m(t)} \left[\ln \frac{m_0}{m(t)}\right]^2$$

the maximum energy transfer (about 8 percent) is achieved when $m_0/m(t) = 5$.

Research on ion beam-driven implosions has made relatively little progress to date. In the future every effort will be made to increase beam power, i.e., to maximize the energy of the accelerated particles and minimize the time width of the compression pulse (e.g., by developing lithium ion diodes that operate at 20-30 MV), as well as to increase beam brightness, improve the angular symmetry of the beam and use new technologies (such as plasma ablation switches and magnetically insulated transmission lines). It is forecast that the break-even point may be attained in 1987-1988.

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APPLIED SCIENCES

VISIBILITY OF TRANSVERSE CRACKS FOR RADIOGRAPHIC INSPECTION OF WELDS IN SPHERICAL VESSELS

Shanghai WUSUNJIANCE [NONDESTRUCTIVE TESTING] in Chinese Vol 6 No 5, Dec 84 pp 40-41, 39

[Article by Xue Jicheng [5641 4949 2110] and Xu Yadeng [1776 0068 3397] of the Jiangsu Electric Power Construction Company]

[Text] This article discusses several factors affecting radiographic inspection of transverse cracks in welds in spherical vessels and draws some conclusions concerning them.

Because of restraining conditions and residual stress from welding, welding seams in spherical vessels can have a rather serious tendency to crack if technical procedures are not strictly adhered to during assembly and installation. The cracks cause a loss of stability and can lead to leakage in spherical vessels, causing accidents.

The results of more than 10 inspections of spherical vessels that were opened indicate that transverse cracks are more numerous in spherical vessel welding seams and that they assume a pattern of radiation toward the center. They generally extend to a depth of 7 to 8 mm. The fact that they are cold cracks means that they can be rather wide. In terms of their distribution, there are more circular cracks than longitudinal cracks, and there are more of them in the inner walls than in the outer walls. This is especially true of the ease of their appearance in the circular seam that is the last to be closed. Moreover, most of them penetrate the width of the welding seams and enter the fusion line and the base metal of the spherical vessel.

There are many methods for nondestructive testing of spherical vessel welding seams to prevent accidents, and each has its own characteristics. This article mainly will discuss factors that affect the use of radiographic methods to make such cracks visible.

I. Direction of Cracking and Effects on Visibility

In the welding seam shown in Figure 1 with a width x and a linear attenuation coefficient of μ, there are three cracks of similar length that run in different directions. When parallel monochrome ray transillumination is used, the ray attenuation law applies, and we can derive:

$$I_1 = I_0 e^{-\mu x} \quad (1)$$

$$I_2 = I_0 e^{-\mu(x-\Delta x)+\mu \cdot \Delta x} \quad (1a)$$

$$\frac{I_2}{I_1} = e^{(\mu-\mu_1)\Delta x} \quad (1b)$$

I_1--the intensity of the rays after passing through a welding seam of thickness x.

I_0--the intensity of ray incidence on the welding seam surface.

I_2--the intensity of the rays after passes through welding seams in the area of the defect.

e--the lower natural logarithm, which is roughly equal to 2.7.

μ_1--the linear attenuation coefficient of the crack components.

Δx--the path the rays take in passing through the defect.

Obviously, in order to obtain an image of the cracks on the photographs, there must be a certain difference between rays I_1 and I_2 on the exposed film. The greater the difference between I_2 and I_1, the greater the detection of defects. Because the three defects shown in Figure 1 have an identical μ_1, I_2/I_1 will be determined by Δx. The Δx of the three defects can be seen easily in Figure 1. They are a > b > c. Crack c, which runs perpendicular to the rays is the hardest to see.

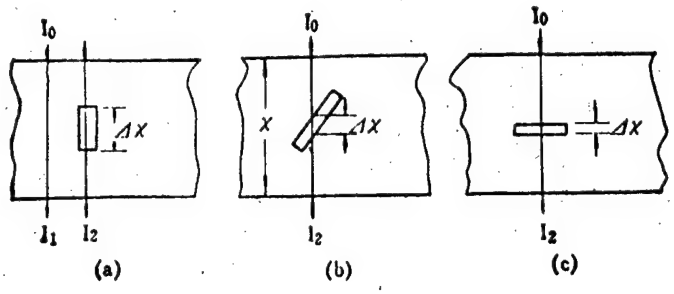


Figure 1. The Effects of Crack Direction

II. Effects of Focal Length on Crack Visibility

Although transverse cracks in spherical vessel welding seams have the characteristic of radiating toward the center and have a direction similar to crack a in Figure 1, radiographic inspection of welding seams requires that a certain line source be used inside with the film placed outside because of the beam emission actually used. Moreover, the focal length will not necessarily be the same as the radius of the spherical vessel. For this reason, with the exception of the center rays of the beam, the remaining rays will form a certain transillumination angle α when they strike a transverse crack. This causes Δx to become smaller and affects the results of the inspection.

We now will use a spherical vessel with a volume of 400 m^3 and a radius of 4,570 mm to illustrate the relationship between changes in focal length and the transillumination angle when using radiographic methods.

1. Transillumination with the line source on the inside and the film on the outside can be used (Figure 2). When the line is of a given length, if the line source (the focal point of the radiography machine) is placed at the center of the spherical vessel, then all of the beams will have a transillumination angle α of 0°. If the line source is moved from the center of the sphere to its periphery, which reduces the focal length, the transillumination angle α obviously will become greater with a reduction in the focal length and an increase in the beam emission angle ϕ. At this time, the transillumination angle α of the rays can be derived from the radius of the spherical vessel R + δ (OB) and the distance between the line source and center of the sphere, which is the difference F between the radius and the focal point + δ (OA), and ϕ:

$$\sin\alpha = \frac{[R-(F-\delta)]\sin\phi}{R+\delta} \qquad (2)$$

In the formula, δ = the wall thickness of the spherical vessel (in mm).

For example, when transillumination of the above spherical vessel uses a focal length of 600 mm, the angle of divergence β is 5° and the transillumination angle α of the rays at the end of the film is:

$$\sin\alpha = \frac{[4570-(600-32)] \times 0.0872}{4570+32} = 0.0758$$

$$\alpha = 4.34°$$

If the focal length is reduced to 300 mm, then the angle of divergence of the beam changes to 10°, while the transillumination angle α at the end of the film is about 9.3°.

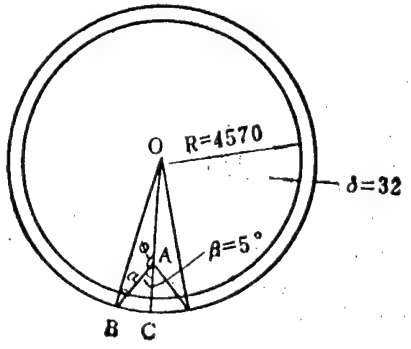
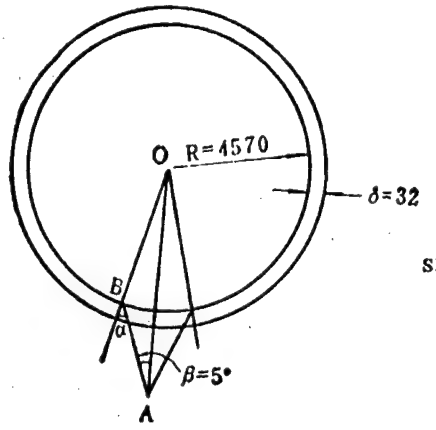


Figure 2. Illustration of the Derivation of Focal Length and Transillumination Angle During Transillumination With the Line Source on the Inside and Film on the Outside

2. Transillumination with the line source on the outside and the film on the inside can be used (Figure 3). When the length of the film is given, there will be a certain transillumination angle regardless of the focal length. Like transillumination with the line source on the inside and the film on the outside, there is a regularity in which the angle of beam divergence becomes greater and the transillumination angle of the rays at the end of the film increases as the focal length becomes smaller. Based on the known beam divergence angle β, the focal length F, the radius of the spherical vessel R and other values, the law of sines for an arbitrary triangle can be applied to derive the transillumination angle α of the rays at the end of the film.



$$\sin\alpha=\frac{(R+F)\sin\beta}{R}$$

Figure 3. Illustration of the Derivation of Focal Length and Transillumination Angle During Transillumination With the Line Source on the Outside and Film on the Inside

For example, when a 600 mm focal length is used for transillumination of the spherical vessel described previously, if the divergence angle β is 5° the transillumination angle α of the rays at the end of the film is 5.6°. If the focal length is reduced to 300 mm, the beam divergence angle β becomes 10°, while the transillumination angle α of the rays at the end of the film is about 10.7°.

We can see from the above that under identical focal length and beam divergence angle conditions, the transillumination angle for transillumination with the line source outside must be greater than that of transillumination with the line source on the inside.

III. Effects of Film Length on Crack Visibility

If there is a set focal length when doing radiographic inspection of welding seams in spherical vessels but different lengths of film are used, then the beam divergence angle will have the following relation to them:

$$\beta=\frac{L/2}{0.01745F} \qquad (3)$$

For this reason, a greater film length L leads to a greater beam divergence angle β and a greater transillumination angle ω of the rays at the end of the film. Table 1 shows the relationship between film length and beam divergence angle when using a focal length of 600 mm with a 400 m^3 spherical vessel. The first part of the British B.S2600 standards stipulate that the following film length L should be adopted when using an exterior line source for transillumination of welding seams in spherical vessels:

$$L=0.017D\left[\cos^{-1}\frac{1}{1.06}-\sin^{-1}\left(\frac{D}{D+2F}\sin\cos^{-1}\frac{1}{1.06}\right)\right] \qquad (4)$$

Here, D is the diameter of the spherical vessel, while 1.06 is the transillumination/thickness ratio, which is δ_{max}/δ. F is the focal distance. For the spherical vessel described above, when the focal length is 600 mm then the film length L that should be adopted according to formula 4 is 362 mm. The beam divergence angle at this time is 17.3°, while the transillumination angle is about 19°.

It is quite obvious that a greater film length also can increase the distance between the crack and the center of the film and can make visibility even poorer.

Table 1. Beam Value With Different Film Lengths in a 400 m^3 Spherical Vessel Using 600 mm F Transillumination

Film length (mm)	20.9	104.7	125.6	146.6	167.5	188.5	209.4	230.2	251
Beam divergence angle (deg)	1	5	6	7	8	9	10	11	12

IV. Effects of Crack Depth on Visibility

The effects of crack depth and distance from the transilluminated surface can be analyzed using the principle of geometric non-resolution for the images formed.

As everyone knows, geometric non-resolution is determined by the focal point of the line source, by the distance between the focal point and the defect and by the distance between the defect and the film. When the focal point measurement and the distance between the defect and the focal point is given, a greater distance between defect and film will cause greater geometric non-resolution in the image of the defect. This means that shallower defects are more difficult to detect.

Nevertheless, for spherical vessels with a wall thickness that is not too great, the crack depth usually has only small effects on visibility. Only

when the wall thickness is greater than 40 mm does the effects of crack depth become apparent. Such effects are much smaller than those caused by the transillumination angle.

V. Effects of Ray Energy on Crack Visibility

The linear attenuation coefficient μ of the transilluminated material is related to the ray energy. It is easy to see from formula 1b that in order to increase I_2/I_1 and to increase the density differential of the defect and test item image on the photograph, then at a certain Δx, low voltage obviously should be adopted to improve the linear attenuation coefficient μ.

In another area, increases in ray energy cause a reduction in the linear attenuation coefficient, which can cause a corresponding decrease in the ratio I_1/I_0, which will reduce ΔD, the density differential of the image of the defect. As ray energy is increased, the degree of weakening in the ray intensity differential at the film is called the scattering ratio n. When other factors are ignored, there is a direct proportional relationship between ΔD and $\mu/(1+n)$. For this reason, when considering the improvement of crack image comparison caused by increasing ΔD, the tube voltage used during transillumination of the spherical vessel should not be too high.

VI. Conclusions

The following conclusions concerning the use of radiography for this type of transverse cracks in welding seams can be drawn based on the above analysis and proof through practice.

1. When the transillumination angle of the rays striking the cracks is >15°, they cannot be detected. When the transillumination angle is 13°, it is rather difficult to detect the cracks. For this reason, it is best if the transillumination angle is no greater than 11°.

2. Transillumination of a 400 m^3 spherical vessel with 32 mm thick walls is limited only by equipment capacity and the desire to improve the speed of inspection. Although the requirements of geometric non-resolution are met when the focal length is 600 mm, the need to assure that the transillumination angle is no greater than 11° as mentioned above means that a rather short film should be used (usually with an effective length of 240 mm). This will reduce the area of transillumination, so determination of whether or not formula 4 is appropriate awaits study.

3. The greater number of cracks on the inner walls means that we should begin with improvement of the geometric resolution of the rays and adopt transillumination with the line source on the exterior and the film on the interior. Because the transillumination angle derived in this manner under identical focal lengths is greater than in a situation with the line source on the interior and the film on the exterior, which aids in detection of transverse cracks, transillumination with the line source on the exterior still is the most suitable.

4. Although in theory one should strive to use a rather low tube voltage if it is capable of penetration, the increased internal scattering of the rays in the low voltage tube makes it hard to ignore the fact that the longer exposure and other factors reduce ΔD. The disadvantages of both methods should be weighed to select the most appropriate one. The tube voltage used for the spherical vessel described above generally was not less than 200 KVP.

5. The above discussion is predicated on the cracks having a certain thickness and that Δx is $\geq$ the transillumination sensitivity. Real cracks, however, sometimes are less than 0.1 mm wide. This makes them difficult to detect when they run parallel with the direction of the rays, which means that the use of radiographic methods for crack detection is greatly limited. For this reason, inspection of welding seams in spherical vessels should adopt ultrasound, magnetic powder, staining and other measures for comprehensive defect detection in order to reduce the non-detection of cracks.

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APPLIED SCIENCES

CHINA'S URANIUM RESOURCES APPRAISED

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5, No 4, Dec 85 pp 289-293

[Article by Wang Jian [3769 7002]]

[Excerpts] A nation's energy policy and its decision-making process of developing strategic and tactical nuclear weapons and the nuclear industry are determined by the quantity and economic values of its uranium resources. Uranium resources affect many aspects of the relationships between nations: politics, economy, trade, and science and technology. The radioactive property of uranium also affects human beings both physiologically and psychologically. For this reason, uranium is a very sensitive strategic material and the development and appraisal of a nation's uranium resources is a very important task. The purpose of appraisal is to determine the quantity and quality of resources and the feasibility and economics of developing the resources. To obtain an objective assessment of uranium resources and to develop practical guidelines and policies for the nuclear industry requires scientific appraisal methods.

Socialist production is the production of commercial goods under planned direction. The production of commercial goods must be concerned with not only utility values but also commercial values, or economic payoff. The production of uranium is no exception. The formation of uranium deposits follow certain pattern, but there are considerable differences in regional distribution, depth of ore deposits, the quantity of reserves, the size and shape of the deposits, and the degree of difficulty in mining and processing. The natural deposit of uranium resources can be estimated by using existing knowledge in geology and engineering techniques, but the degree of confidence in the estimate increases with geological exploration and actual production. The so-called "reliability of estimated reserve" refers to the degree of understanding about the ore deposit. In simple terms, the appraisal of uranium resources is to use scientific methods to appraise the economics and reliability of the uranium resources. Uranium resources can be classified according to the economic payoff of developed uranium mines and the degree of geological exploration; this information can be used as a basis for establishing policies and plans for developing the nuclear industry.

Uranium is a non-renewable natural material. Therefore, the appraisal process must take into consideration the efficient use of this valuable resource in order to minimize loss and waste.

Appraisal of uranium resources involves the following factors:

1. Condition of geological deposit of the resource. The size and quantity of the ore deposit, the spatial position, the uranium concentration, the continuity of mineralization, the properties and structure of earth stratum, and the physical and chemical properties of the surrounding rocks and ore directly affect the depth of exploration, the techniques of mining and processing, and cost.

2. Economics of resource development. The ratio of funds invested in developing the resources and the funds generated by the products is a measure of economic payoff. The factors which affect economic payoff include the grade of the ore deposit, the mining depletion rate, the cost of mining, processing and transportation, the rate of recovery, and the sale price of the product. Of these factors the most sensitive is the ore grade, which can vary from several hundredth of a percent to several percent; in some cases the ore bed itself may vary a great deal in richness. Clearly, an ore bed is economically profitable if the income from the sales is higher than the production cost. In recent years, the price of natural uranium has been dropping drastically on the international market. Many factories and mining operations in the United States and Canada have closed down because of lack of profitability.

3. Technical conditions for mining and hydrometallurgical processing. Because of different deposit conditions, some ore deposits are easy to mine and process, thus production cost is low; some may be easy to mine and process, but the recovery rate is low, hence its economic payoff is poor; others are still unminable or unprocessable using current technology.

4. Political factors. The defense policy, energy policy, foreign policy and trade policy of a nation directly affect the demand, production, and volume of import/export, and the price of uranium resources and uranium products; as a result, they also affect the appraisal of uranium resources.

5. Time factor. With the continuing exploration and development of uranium ores, the quantity and spatial distribution of uranium resources change accordingly. Also, the sale price, production cost, mining and processing techniques, and political atmosphere change with time. Therefore, resource appraisal is a function of time and must be performed periodically.

Countries with uranium resources and nuclear energy organizations devote a significant amount of effort to uranium appraisal. They not only conduct appraisals of their domestic resources but also monitor the uranium appraisals of other countries in order to adjust their own nuclear policies. In the appraisal process, they classify the uranium resources according to their reliability and economics. They also devote considerable amount of research effort to improve the method of appraisal and the method of calculating uranium reserves. During the 12th International Mining

Conference held in New Delhi in 1984, many papers were concerned with the topic of resource appraisal, which illustrates one aspect of the development trend of current technology. We shall now present a few examples of the classification of uranium resources by several countries and organizations.

In geological exploration, it is common practice to use the authorized cost indices for uranium products to calculate the marginal grade of each ore bed and to estimate the uranium reserve according to the ore deposits and the technical conditions of mining and processing. Different marginal grades and industrial indices are used for different ore beds. In resource classification, the best category in terms of economics and reliability is called industrial reserve. It is used for establishing development plans for nuclear energy and for coordinating the fuel requirement during the operating life of nuclear reactors (typically 30 years); it is also used as a basis for establishing guidelines for import and export of uranium products. The categories other than industrial reserve are simply called backup resources; they cannot be used for establishing plans of nuclear energy development. The IAEA generally conducts an appraisal of each country's uranium resources every 2 years. Since 1975, this organization has used "cost" instead of "price" as a basis for appraising uranium resources. Most countries use the "cost" method of appraisal, but Canada still uses the "price" method. Canada has established a Uranium Resource Appraisal Group (URAG) whose members consist of government officials and experts in geology, mining and hydrometallurgy. The group has three branches: 1) The assured resource branch, which is responsible for the authorization of "assured reserve" and calculated reserve, and for estimating the uranium production level based on these reserves; 2) The estimated additional resource branch, which is responsible for the estimation of additional resource, including evaluation of the "predicted resource," and 3) The economic coordination branch, which is responsible for coordinating domestic uranium needs and uranium export, and for determining the uranium reserve required for domestic reactor operation.

The terminologies used by different countries for classifying uranium resources are quite similar.

Many countries are using new technologies, new procedures, and new methods to improve the utilization of uranium resources and to reduce production cost. Radioactive mine selection and immersion mining techniques have been used extensively in extracting low quality level ores, so that some resources have been converted into reserve. By using geological statistical methods to calculate uranium reserve and to guide exploration, the effectiveness of exploration and the reliability of estimated reserve are improved and the quality of resource appraisal is upgraded.

The 30 years of geological exploration since China's liberation have produced considerable amount of uranium resources and have made significant contributions to the development of China's nuclear industry. During the 50's, it was necessary to use the then Soviet theory and method of geological exploration and industrial indices in order to find uranium ore as quickly as possible to meet the military and industrial needs.

During this initial stage of production, emphasis was placed on the effectiveness of exploration; little attention was given to the economics of resource development, and resource appraisal was non-existent. When the nuclear industry has evolved to the stage of "serving the people while meeting military needs," we must be concerned with the economic payoff in nuclear power generation, and we should promote the appraisal of China's uranium resources.

To begin this new era of uranium resource appraisal, we must take a very practical approach. Here are some suggestions:

1. Preparation for uranium appraisal. We suggest that a special appraisal group be organized by the Radioactive Mineral Special Committee to be solely responsible for the appraisal of uranium resources; members of this group will include experts in geology, mining, hydrometallurgy, and technical economics. The group will be tasked to develop the basic concepts and guidelines for appraisal of China's uranium resources, to specify the classifications and standards of uranium resources based on economic payoff and reliability, and to define the necessary technical/economic indices as well as appraisal theories and methods; they will also be tasked to publish an "Appraisal Standards" which will be used in appraisal work after being submitted for approval.

2. Appraisal of uranium resources which have already been submitted. For those reserves which have been submitted and approved by the reserve commission, the original industrial indices and reserves can be used to estimate the production cost and to determine the classification of each ore bed according to the "Appraisal Standards." The reserve which has been depleted and written off will not be appraised. The ore beds which are under construction will be appraised and classified according to the assessed initial deposit and the degree of development. Ore beds which have not been constructed will be appraised and classified according to the approved reserve. Resources which have not been approved by the reserve commission must first be approved before appraisal.

The appraisal of each ore bed requires estimating the amount of recoverable uranium and the cost of producing 1 ton of natural uranium. Based on China's current production level, the cost of producing 1 ton of uranium can be divided into 10 50,000-yuan segments between 0 and 500,000 yuan. By determining the cumulative number of resources in the same cost segment, an uranium cost curve can be constructed. Also, based on the current production level, a profit-loss curve of China's uranium mines can be generated (e.g., assuming the cost of uranium per ton to be 220,000 yuan, based on 80 U.S. dollar per kg). The projection of the point of intersection between the cost curve and the profit-loss curve, A, is the cumulative uranium resource that may produce a profit. Thus the resource between A and 0 is economical resource. The resource between A and B is sub-economical resource, whose cost may be lowered to the break-even point on the profit-loss curve through improved technologies and management. The resource beyond the point B is uneconomical resource, which will not be considered for development within 20 years.

3. Appraisal of newly explored resources. For future exploration of uranium ores, the original indices used by the Third Five-Year Plan are no longer applicable; new industrial indices based on current conditions must be specified for general search and exploration. After initial exploration is completed, the geological, mining and processing conditions of a particular ore bed should be examined to determine the most appropriate industrial indices to be used for guiding detailed exploration, calculating reserve for the final geological report, and for resource appraisal and ore development. For those resources which are technically not feasible, economically non-profitable, or are not recommended for development within an extended period, detailed exploration will not be initiated in order to avoid premature commitment of valuable funds.

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APPLIED SCIENCES

DRY VACUUM DISTILLATION DISCUSSED

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[Text] In recent years, China's annual crude oil output has approached about 100 million tons. Of this, the yields of straight-run gasoline, kerosene and diesel oil depend on the crude but generally total 25-30 percent of the crude oil. By vacuum distillation of the remaining atmospheric heavy oil, another 20-30 percent distillates are obtained and used as basic stocks for: lubricating oils and paraffin wax; catalytic preparation of gasoline and diesel oil; and the production of petrochemical feedstocks by pyrolytic cracking. To avoid the decomposition at high temperature of heavy oil inside heating furnace and pressure reducing tower, which would affect the quality of distillate oils, superheated steam is injected into furnace coils and tower. The traditional wet vacuum distillation tower operates under 50-150 mm Hg in the flash zone. Recently, dry vacuum distillation, which is operated at higher vacuum and without steam injection, has been developed both in China and abroad. It can be used to improve the yields of gasoline and diesel oil as well as to increase the production of petrochemical feedstocks.[1] If this method is widely adopted in China, oil refining alone could result in increased production with an economic benefit of over 600 million yuan.

I. Advantages of Dry Vacuum Distillation

The advantages of dry vacuum distillation over traditional wet vacuum distillation, as determined from practical experience, are:

1. Improved Distillation Yield of Desired Products. The increase of distillation yield is 2-5 percent of the feed or 1.4-3.6 percent of the crude. In recent years, we have processed over 70 million tons of crude. If wet vacuum distillation is totally replaced by dry vacuum distillation, additional amounts of distillate oils can be further cracked catalytically to yield about 1.225 million tons more of gasoline and diesel oil, and equivalent to an increase in output value of over 500 million yuan. The economic benefit would be even more substantial if they are converted into petrochemical products.

2. Energy Savings. Because there is no steam injection into heating furnace coils and decompression tower, the total amount of steam in the decompression system can be reduced by 50-70 percent. The cooling load of the decompression system for refineries with an annual processing capacity of 3 million tons of crude can be reduced by 3 million kcal/hr, which results in tremendous savings in heating fuels. The energy consumption for atmospheric and decompression installations are reduced from 223,900 kcal/ton of crude to 132,200 kcal/ton of crude. If 70 million tons of crude is processed in China, the saving in fuel oil can be 641,900 tons, which is valued at 86.015 million yuan.

3. Improved Tower Capacity. When metal stacking ring packing is used, the capacity of a dry decompression tower can be raised by about 30 percent while pressure drop through the tower can be reduced by about 50 percent. Or for the same capacity of 1.32 million ton/year, the diameter of the decompression tower can be reduced from 8.34 meters to 5.79.

4. Small Pressure Drop, Good Heat Transfer, Large Operational Flexibility and Certain Degree of Fractionation. The pressure drop of the dry decompression tower with the new type of packing is only 1/3-1/5 that of the plate tower. The cross-sectional production capacity of the tower for wax oil ranges from 25,400 to 45,000 ton/year·m^2. Over 1,000 units of dry decompression tower are being used abroad mainly for absorption, stripping and distillation.

II. Operation and Design Principle of Dry Vacuum Distillation System

Under the prerequisite of assuring the quality of distillate oils, the specific measures to raise yield, and to lower energy consumption, production cost and initial investments as well as to raise operational flexibility are as follows:

1. Decompression Heating Furnace

Without causing thermal cracking of oil feed, the furnace outlet temperature can be higher in order to increase the yield of distillate oil. When the feed is the mixed crude of the Shengli oilfield, the furnace outlet temperature should be kept below 393°C. When oil feed is low, temperature can be lowered to save fuel.

2. Transfer Line Between Furnace Outlet and Tower

Slow speed transfer lines are generally used. Distillate oils are completely vaporized inside the section of straight tube extending 15 meters before the tower and enter the tower at the velocity of 42-54.86 m/sec. The slow speed sections of the line are supported with soft and elastic supports to avoid vibration. The flow velocity in other parts of the transfer line is 120 m/sec to allow the evaporation rate of the feed inside the furnace and transfer line to reach 90 percent or more of the overall evaporation rate. This way, the carry-over of the condensate within the transfer line into the tower can be avoided so that the contents of residual carbons and heavy metals in

side-draws at the bottom of the decompression tower are sure to meet specifications. The pressure drop inside the transfer line is 90-250 mm Hg, the temperature drop is 5.6-14°C and the temperature drop between the tower inlet and the flash zone is 7-8°C. The bending stresses are largest at the transient section between the furnace outlet pipe and the slow flow section as well as the junctions between slow flow sections where vibration occurs due to gas expansion. Totally flexible supports should be used at these places and rolling brackets are installed between the support and the line. This line is connected to the decompression tower with a grade of 0.003. Reinforcing plate is welded at the joint of the two lines. Bumper plates are welded at the bottom of the slow flow line and baffling measures should be adopted after the feed enters the tower.

3. Dry Decompression Tower

The feed enters into a flash zone above the residuum section at the bottom of the tower. On top of the feed section are the washing section and the condensing zone in ascending order.

(1) Flash zone. The pressure of 15-30 mm Hg (absolute pressure) at this zone is appropriate for the primary equilibrium flash separation of gas and liquid phases. The design condition for the evaporation temperature is a junction of the properties of feed oil and the required distillation yield, and is greatly affected by the flash zone pressure. When all other factors remain constant, for every 10°C increase in flash zone temperature, the distillation yield can be raised by 2.3-4 percent (weight) or, for a 10 mm Hg decrease in pressure, the wax oil yield increases by 1-5 percent (weight). Under the condition of constant capacity and distillation yield, when flash zone temperature drops from 381°C to 360°C, then flash zone pressure should drop from 73 mm Hg to 27 mm Hg (absolute pressure). The overhead pressure drops correspondingly from 70 mm to 10 mm (absolute pressure) and pressure drop through the tower rises from 3 mm Hg to 17 mm Hg. The fuel consumption of heating furnace decreases by 19,200 kcal/ton of feed but the energy consumption of the vacuum system increases. The overall energy consumption decreases by 8,100 kcal/ton of feed. With 70 million tons of crude processed nationally, then the annual savings in fuel oil is 100,000 tons (assuming furnace efficiency of 81 percent). Therefore, there is significant economic benefit in reasonable design and manipulation of flash zone temperature, pressure and distillation yield.

(2) Washing section. It washes away the majority of heavy metals and residual-carbon entrained in the ascending vapor and thus guarantees the quality of distillate oils. It also reduces overflash and saves energy. The excess overflash oils are either returned to residuum or blended with fuel oils. The overflash is 2-3 percent of the feed. The minimum spray density of wash-oil is 1 $m^3/m^2 \cdot h$. To assure the quality of distillate oils, the amount of wash-oil cannot be reduced even when the load decreases.

(3) Condensation zone. Here the ascending product oils are condensed and drawn into collecting boxes. This is mainly done by primary equilibrium condensation. Packed sections or trays work as long as there is enough heat

exchange area. The collecting boxes isolate each side-stream into independent section. There is no inner reflux passing between them. Because of the condensation, the volume of gas at the bottom of a packed section is 5-10 times that at the top.

(4) Side-streams of the tower. The number of side-streams should be based on the overall consideration of investment, heat recovery, feed load, number of mechanical pumps, length of line, size of lot and operation management. One side-stream is chosen when the feed load is less than half million tons/year; two side-streams when the fuel exceeds 1 million tons/year. Currently, several dry vacuum towers for the feed load of 30,000-100,000 tons/year are in the design stage. But the number of side-streams is being examined adequately. The situation should be corrected.

(5) Feed and reflux heat distribution for each side-stream. More head can be recovered when using two side-streams. The ratios for feed distribution and reflex heat distribution of the two side-streams are best under 40:60 and 20:80, respectively.

(6) Overhead temperature. When overhead temperature is 90-100°C, the amount of topped oil is more than 1 percent of the feed oil and is almost non-existent at 45°C. The temperature of the topped oil is set at 60-80°C, which is 15-20°C higher than the top reflux temperature.

(7) Tower bottom temperature. It should be designed to be 1-3°C lower than the flash zone temperature.

(8) Reflux temperature difference. The designed approach temperature difference (the difference between the reflux temperature and the temperature of the vapor phase leaving the zone) should be no less than 30°C. The reflux temperature difference (the temperature difference between the returned and draw-off of the reflux oil) should be 80-100°C.

(9) Heat loss from the tower. The heat loss of the tower is 5 percent when the diameter of the tower is larger than 5 meters and is about 8-10 percent when smaller than 4 meters.

(10) Basic components of gas-liquid phase contact. The rectifying section of the tower is also the condensing section. The main function of tray or packing is heat transfer rather than mass transfer. To get a higher yield from the flash zone at constant temperature, the metal packing with slow flow resistance should be chosen. Considering investment, those dry decompression towers with new model vertical sieve trays[2] or combined gasketed tray and packing should be chosen. The combination type is five times cheaper than the all-packing type. Useful packings are the Interlex packing that allows large flux and small pressure drop and the Glitsch grid-stabilizing ring combination bed packing that is remarkably effective with regard to reducing tower diameter, saving investment, increasing feed load and reducing pressure drop. The Glitsch grid packing can be used for a large diameter wash zone; and the stacking ring or Interlex packing combination bed can be used for the heavy vacuum gas oil zone. Their height ratio is 1:2. The random

packing is best suitable for the light vacuum gas oil packing zone. The packing glands and bolted nuts should be used inside the tower in order to keep nuts from becoming loose under repeated poundings. When packings are loaded for the first time, they should be sprayed with water to settle before glands can be installed.

(11) The diameter of the tower at packing layer.[3] When processing a constant amount of feed, the tower diameter at the packing layer is influenced by the type of packing. The equation is as follows:

$$D=\sqrt{\frac{\theta_V}{0.785\times 3600\omega}}=0.0188\sqrt{\frac{\theta_V}{\omega}}\text{[m]} \quad (1)$$

$$\omega=\frac{C}{\sqrt{\frac{\rho_g}{\rho_L-\rho_g}}} \quad \text{[m/sec]} \quad (2)$$

where: D--tower diameter [m], θ_V--gas phase flow rate inside the tower [m^3/h], ω--flow velocity with tower empty [m/sec], ρ_g--gas phase density [kg/m^3], ρ_L--liquid phase density [kg/m^3], C--packing volumetric factor [m/sec].

In general, the maximum capacity of dry vacuum distillation tower is the production of 31,000-41,300 tons/year of crude diesel oil per square meter of tower cross-section.

(12) Packing height.[3] It is related to gas phase flow velocity, liquid phase load, approach temperature difference, existing water vapor and non-condensable gas.

$$\text{Packing height } H=\frac{Q}{K\cdot\Delta t\cdot F} \quad \text{[m]} \quad (3)$$

where: Δt--logarithmic average approach temperature difference [°C], Q--heat load of sectional packing [kcal/h], K--heat transfer coefficient [$kcal/m^3\cdot h\cdot °C$], F--cross-section of tower [m^2].

The K values for ϕ50 stacking ring and 50# Interlex are described by:

$$K=1363C^{0.286}L^{0.762} \quad [kcal/m^3\cdot h\cdot °C] \quad (4)$$

where: C--average volumetric factor of packing [m/sec], L--average liquid phase load [$m^3/m^2\cdot h$].

For the overhead volumetric heat transfer of packing, the numbers of 180,000-250,000 $kcal/m^3\cdot h$ are used and, for the packing height of wash zone, 1-1.3 meters are used.

(13) Draw trays. They store and retain liquids for 2-3 minutes. Concentric round holes are placed on the inner core of draw trays for the passage of ascending vapor, whose velocity is controlled at under 10 m/sec. Hole ratio

of 30 percent is good. There are no orifices on the bottom plate of the tray and outlet is placed beneath the bottom plate. At the end of operation, collected liquid is emptied into draw-off system. The quality and mode of weldings between the bottom plate and tower wall should be such that they will not crack under high and low temperatures. After the completion of this job, the quality of weldings should be checked by filling trays with water and let sit for 24 hours. Because of the high viscosity of oils, the ball float liquid level indicators are used in draw trays. When coupled with the regulating valve on the product draw-off line, the liquid level inside draw tray can be automatically controlled. An 800 mm space for uniform distribution of vapor should be maintained between the top of the draw tray and the support plate for "camel's hump" packing above it. Manhole is not necessary for draw trays. If floating ball drops out of its place, it can be retrieved from the opening of ball float liquid level indicator (whose diameter is 250 mm).

(14) Tower height. Manholes should be properly positioned based on the ease of installation and maintenance. The height of liquid storage funnel at the bottom of the tower should be such that the residence time of oil feed is 3-5 minutes. To reduce mists and foams entrained in the ascending vapors, which would affect the contents of heavy metals and residual carbons in the product petrolatum oil, the distance from the center of feed inlet to the bottom of draw trays at the upper part of the tower is determined according to the equation $A = 0.2D + 1.2$ [m] and the distance from the center of inlet to the cross-section of bottom head, $B = 0.2D$ [m] (D is the tower diameter in meters). The individual draw tray height is 0.35 meter. It is better to equally space draw tray, grid packing and ejector head by 0.45 meter.

(15) Liquid distributor. It is an important factor in determining the packing efficiency on liquid. The liquid distribution is good when the liquid pressure is maintained at 1-3 kg/cm^2 and forked tongues are 90° from one another on the spinning ejector head. The ejector head of 1Cr18Ni9Ti is recommended for the crude from Shengli oilfield and other corrosive oils. Sixty mesh filter should be installed before the ejector head. The performance of ejector head can be checked with water instead of oil with negligible error.

(16) Distribution cone. It keeps liquid from being sprayed onto tower wall that will cause undesirable wall effect. It is made by rolling a piece of 60 mm wide thin steel. These cones are positioned 150-200 mm above the surface of packings and welded to tower wall at 45° angle.

4. Evacuation System

When the residual overhead pressure is 11 mm Hg and compression ratio of pressure booster is 7, the exhausting device is operable with 16 kg of saturated steam at a pressure of 9 kg/cm^2, per ton of crude. This is a saving of about 7.7 kg of saturated steam per ton of crude over wet vacuum distillation. The suction vapor load of exhausting device is reduced by 80-90 percent over wet vacuum distillation. When processing the mixed crude of Shengli oilfield, the amount of noncondensables is 0.08 percent of vacuum

feed while overhead condensables is 0.2-0.48 percent. The steam ejector should be placed horizontally or vertically but never upside-down. Pressure booster should be positioned near the overhead to minimize the length of pipe and resistance from the overhead to pressure booster. Energy savings have been achieved by using mechanical vacuum pumps or vacuum devices that are coupled with steam ejectors.[4] The gas outlet of cooling condenser should be placed on the outlet pipe at the lower section to prevent vapor from taking shortcuts through the orifices on baffles. The last stage condenser can be installed on the platform at the bottom.

In summary, replacing wet vacuum distillation with dry vacuum distillation not only can improve yield but also save energy and provide good operational flexibility. It is one of the good measures for realizing the four modernizations in oil refining and the chemical industry.

Note: The assistance and guidance of Zhang Youshi [1728 0645 4258], chief engineer at Jinling Petrochemical Corp., Qiu Guoqi [6726 0948 0892], director of Loyang Research Plant of [Jinling] Petrochemical Corp., Zhu Renyi [2612 0086 5030], chief engineer at Shanghai Gaoqiao Petrochemical Corp., Sun Bairen [1327 4102 1804], deputy director of Wuxi Chemical Industry Bureau, Jiang Hu [1203 3338], Wu Xiangchen [0702 3276 5256], and Ji Gang [1323 6921], engineers at Wuxi Resin Plant, are acknowledged.

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ENVIRONMENTAL QUALITY

DISPOSAL OF RADIOACTIVE WASTE FROM PWR REACTOR

Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 12, 5 Dec 85 pp 69-73

[Article by Tang Zongyan [0781 1350 3508], Science and Technology Information Institute, Ministry of Water Resources and Electric Power: "PWR Nuclear Power Stations: Handling of Radioactive Wastes From a PWR Reactor and Impact of Radioactive Discharge on the Environment"]

[Text] I. Handling of Radioactive Wastes

The fuel uranium used in PWR is uranium ore which is extracted from underground and which, after a complex process of sorting, refining, chemical conversion, enriching, and processing, is manufactured into fuel elements. This processing of nuclear fuel before placing it in the reactor is generally termed "preprocessing." After "burning" in the reactor, the uranium fuel should be "postprocessed" to recover uranium which has not been fully consumed and the plutonium which is produced and also to extract some fission products and transuranium elements. The entire process from extraction of the uranium ore to the recovery of radioactive nuclear elements in the spent fuel is called "fuel recycling." Radioactive wastes are produced at each stage. This paper is a brief introduction to the handling of radioactive wastes produced only in the operation process of a PWR power plant.

The large quantity of radioactive material produced by nuclear fission in the operation of a nuclear power station is the main source of a nuclear power plant's radioactivity. Neutron capture reactions also form a certain quantity of transuranium elements and activated products of the structural materials. When the fuel element casing is damaged, some fission products can enter the coolant. After the structural part of the reactor has undergone corrosion or damage, activated products of the structural materials also can enter the coolant. In addition, when impurities in the coolant pass the reactor core, they can also become radioactive due to neutron radiation.

It is necessary strictly to collect, handle and control radioactive wastes produced during operations in the nuclear power plant to prevent radioactive materials which exceed the maximum allowable concentration from being discharged into the surrounding environment. For this reason, radioactive waste collection and handling systems have been established.

1. Source and Handling of Radioactive Gases

Below we explain the source and handling methods of the waste gases produced during ordinary operations.

(1) Exhaust gases from volume control tanks and other equipment

The gases used in a circuit of a PWR nuclear power plant include hydrogen gas, which is added to the coolant to inhibit corrosion, and nitrogen gas, which is used as a cover gas in the water tanks. The hydrogen is added to the volume control tanks to maintain the hydrogen concentration in the coolant. In the gas in the volume control tanks and the water tanks, the hydrogen or nitrogen mix with the radioactive gases given off by the reactor coolant. Thus the gas which is replaced and expelled in the volume control tank during starting and stopping the reactor and the cover gas which is expelled as the water level rises in the water tanks during operation both are waste gases which are radioactive. In addition, gases are expelled when the boron recovery equipment is operating. These gases are stored in the gas decay tank for a certain period of time so that the short-life krypton, xenon, and iodine isotopes in the waste gas drops more than 99.9 percent, then they are either expelled or reused, depending on the strength of the radioactivity and composition of the gas.

Recently, hydrogen recombination or separation devices have been installed in some PWR power plants. The hydrogen recombination device is made up of a preheater, catalytic reactor, cooler and water separator. The waste gases containing hydrogen which are expelled from the gas space in the volume control tank are forced into the catalytic converter by the waste gas compressor and with the introduction of appropriate amounts of oxygen and the reaction with the surface of the catalyst turns it into water and steam which thus reduces the concentration of hydrogen. The water in the gas mixture is eliminated through the cooler and the water separator. The remaining gas is transported from the recombination device to the hydrogen recombined gas decay tank and then returned to the compressor inlet where it completes the cycle. Within the cycle, after the remaining concentration of hydrogen bearing waste gas has reached a low level, it is sent to the waste gas decay tank.

The exhaust gases of these devices go through exhaust gas collector tubes and are sent by the waste gas compressor to the gas decay tank for storage. For example, when the coolant is drawn off to adjust the iodine concentration and due to heat expansion in the cooling system is sent to the holding tank, the waste gases expelled in the gas space of the holding tank enters the exhaust gas collection tube as waste gas.

If the radioactive gas stored in the gas decay tank is largely nitrogen and the oxygen concentration in the gas is below the limit, this gas can be reused as a cover gas in the holding tank; if it exceeds the limit, then it is held for a certain period of time before discharge.

(2) Reactor safety shell ventilation

If the cycling coolant within the reactor's containment shell leaks, radioactive material will contaminate the ventilation. In addition, some of the Ar-40 in the air is converted into Ar-41 through neutron radiation around the reactor container. Therefore, when workers enter the containment shell after the reactor stops the air must be changed by containment shell ventilation and air conditioning equipment. After the air has been changed, the expelled gases first go through containment shell air cleaning equipment, and the radioactive grains and iodine eliminated from the air by particle filters and iodine filters, then it is expelled by an exhaust fan through the containment shell stack.

If the containment shell pressure rises to near a designated value during operation of the reactor, it is necessary to exhaust a small amount of air through radioactive ray control room exhaust gas filtering equipment made up of particle filters and iodine filters to reduce pressure.

(3) Reactor auxiliary building ventilation

If the cycling coolant in the reactor's auxiliary buildings leaks, some radioactive material will contaminate the air. Auxiliary room and safety auxiliary room ventilation exhaust ordinarily is expelled after the auxiliary building exhaust filter equipment (microparticle filter) eliminates radioactive microparticles. Ventilation exhaust of the waste fuel holding pool is expelled after the fuel storage exhaust filter equipment (microparticle filters) eliminates radioactive microparticles.

When any waste gas is released its concentration of radioactive matter is monitored by the gas monitor and is expelled from the stacks in diluted form.

2. Sources and Treatment of Radioactive Waste Liquids

The following types of waste liquids are produced during normal operation:

(1) Water drawn to regulate boron concentration of circulating coolant is taken to the holding tank.

(2) Coolant drain-off from the containment shell and the auxiliary buildings is taken to the containment shell coolant drain-off tank and the auxiliary buildings coolant drain-off tank.

(3) Depending on water quality, the drainage water of auxiliary building equipment is taken to the A waste fluid storage tank, B waste fluid storage tank or auxiliary building equipment shu drainage tank.

(4) The containment shell surface drainage and the auxiliary buildings surface drainage is collected in the containment shell catchment pond and the auxiliary buildings catchment pond.

(5) Chemical drainage from the chemical room is taken by the chemical drainage tank.

(6) Washing drainage, i.e., laundry drainage, washroom drainage and bathing drainage, is taken by the washing drainage tank.

There are four handling systems in the waste water handling equipment: boron recovery system, A waste water treatment system, B waste water treatment system, and washing drainage treatment system. Each type of waste water is handled by one of these systems.

Water drawn off from the circulating coolant and drainage from the containment shell and auxiliary buildings coolant is treated by the boron recovery system to separate the boric acid from pure water. This system consists of the boron recovery intake ionic exchanger, coolant storage tank, boron recovery equipment, boron ion removal exchange, boric acid concentrate tank, and monitor. After the waste liquid has been cleaned of ionized matter by the ion exchanger and stored in the coolant storage tank, the boron recovery degassing column of the boron recovery equipment separates the soluble gases (the separated gases are treated as waste gases). The soluble solid matter concentrations in the degassed coolant are separated by the evaporator in the boron recovery equipment. After going through the boron ion exchange, the condensation obtained by the evaporator is reused as recharging water for the reactor. The concentrated liquid is reused to recharge the boric acid solution. Before use it must be chemically tested to check if it conforms to reuse standards.

Water from the drainage of the auxiliary buildings equipment which is of low conductivity and high purity (A waste liquids) is treated by the A waste liquid treatment system. Waste liquid is first stored in the A waste liquid storage tank, then the soluble solid matter concentrations are separated by the waste liquid evaporation equipment. After the condensate obtained by evaporation has gone through the ion exchange to improve its purity, in principle it can be reused as recharging water. After curing, the concentrated waste liquid is treated as solid waste.

B waste liquids, containment shell and auxiliary building surface drainage in the shu drainage from auxiliary building equipment is processed by the B waste liquid treatment system. The treatment steps in the B waste liquid treatment system are similar to those in the A waste liquid treatment system. The only difference is that the condensate obtained by evaporation is not recovered, but is sent to the condensate tank through the ion exchanger, and after determining here that the radioactivity is low it is diluted with the condenser coolant and discharged through the drainage outlet. After curing by the barrel packing equipment, the concentrated waste liquid is treated as solid waste.

Laundry drainage in principle is treated by the laundry drainage treatment system. The soluble radioactive material in the waste water is separated by the laundry drainage treatment equipment, the condensate (or shentoushui

[2334 6631 3055] obtained through evaporation is sent to the laundry drainage monitoring trough and after making sure that the radioactivity is very low, it is diluted with condensate coolant and drained through the drainage outlet. The concentrated waste liquid is sent to the barrel packing equipment and treated as solid waste.

3. Sources and Treatment of Radioactive Solid Waste

Most radioactive waste produced by nuclear power stations is ultimately concentrated into solid waste. This solid waste is of medium and low radioactive level in the entire fuel cycle and after 300-500 years in storage can reach a harmless level. Most countries use land storage as the method for permanent disposal, i.e., an area which is geologically stable and has a low water table is selected for construction of a permanent waste dump collecting the solid waste of many nuclear power stations for permanent storage. Many abandoned mines, such as salt mines, limestone mines, and gypsum mines can be used as waste dumps. Many coastal countries use marine dumping as a permanent disposal method, i.e., tightly sealed solid waste is dumped into the deep sea where it is geologically and hydrologically stable. In recent years, marine dumping of radioactive wastes has come to be opposed by more and more people.

Before final disposal, solid wastes are stored in waste dumps inside the power station. The processing methods used are: curing in barrels in cement or asphalt or compacted by such methods as incineration, compression, crushing, dissolution.

The types of solid waste and the methods for solid waste treatment are as follows:

(1) The concentrated waste liquid from the waste liquid evaporation equipment and laundry drainage processing equipment is piped to the loading equipment which loads it into cement or asphalt curing barrels.

The strong acids in the chemical drainage are loaded into cement curing barrels by the loading equipment.

(2) The waste resins from the ion exchanger are piped to the waste resin tank for storage after being stored temporarily in the waste resin tank. The water used for piping is supplied by the reactor water supply tank. After the waste resins have been in the storage tank for approximately one year, have decayed to low radioactivity, they are sent to the loading equipment and loaded into barrels after the water has been extracted. The water which has been extracted can be recycled and must not be discharged.

(3) Miscellaneous solid waste, such as cloth, paper, and small tools, is generally treated by the compression method, that is, the crusher compacts crushable solid wastes into barrels to reduce bulk. Where there is incineration equipment, combustible solid waste and waste oil can be incinerated, and the ash and used and damaged ceramic filter cores packed into barrels after being crushed.

Miscellaneous solid wastes which cannot be compressed are sealed in barrels or cans depending on size and degree of contamination or measures such as binding to prevent the spread of the contamination are adopted.

(4) Used liquid filters are bound to prevent radioactive matter from scattering.

II. Impact of Radioactive Matter on the Environment

In the operation of a nuclear power plant it is unavoidable that some radioactive matter is released into the surrounding environment, just the same as thermoelectric power plants or other production processes cannot help but release some pollutants. However, nuclear power plant design can keep the radioactive discharge much lower than the degree to which they will influence the health of residents. In fact, radioactive discharge from nuclear power plants is unusually low, even to the point of being very hard to detect.

Now, nuclear power plant radioactive waste liquid discharge is limited to a level at which the residents in the surrounding area receive a dosage of no more than 3 mrem annually. Gas discharges are limited to a dosage of no more than 5 mrem received by a hypothetical man sitting on the boundary fence for 24 hours a day for a 365-day year and dosage no greater than 1 mrem received by residents in the vicinity of the power station. Compared with this dosage, the natural background radiation is 100-150 mrem (fluctuation of 20-30 mrem) annually, and the medical radiation received annually is 70-80 mrem. Thus, the increased dosage of radioactivity received by residents in the vicinity of a nuclear power plant due to the plant's radioactive discharge is less than 1 percent of the dosage they receive from natural radioactive sources. Actually, the radioactive dosage received from a nuclear power plant is less than the variation in natural background radiation. The dosage received by people who live a certain distance from a power plant should be much smaller. From this it is clear that the comparison of the environmental dosage created by nuclear power plants and the environmental dosage created by other radioactive sources with natural background radiation is insignificant.

Since 1958, nuclear power plants world-wide have accumulated over 3,000 reactor/years of operating experience, and there has never been a fatal accident caused by radioactivity. This is because in nuclear power plant design, the most harmful accident scenarios are used as the basis of design. The typical worst-case scenario is: the largest pipe which most threatens the safety of the power plant suddenly is thoroughly ruptured, and the safety safeguard systems and safety injection systems cannot function normally leading to a massive loss of coolant and the creation of a meltdown of the reactor core. The frequency of such incidents is 10^{-5}-10^{-6}/reactor year, which is unusually small.

If all the engineered safety measures to prevent such an accident fail completely and a reactor fuel element meltdown occurs, the containment shell

and safety sprinkler system still can limit the range and impact of the accident's aftereffects. However, at this time the containment shell will release a certain amount of radioactive matter into the surrounding environment. At this time there are still final protective measures to safeguard the environment and the physical health of the nearby residents, and this is the plant's isolation region.

According to estimates of the U.S. Nuclear Regulatory Commission, 98 percent of the reactor core meltdowns could not cause clear human fatalities. The number of average fatalities per reactor core meltdown is 10, and the most serious reactor core meltdown (worst case-scenario) may cause 3,500 fatalities. As stated above, up to the present there has not been an accident in which release of radioactive material from a nuclear power plant has caused a fatality. But historically, personal accidents related to energy sources have always occurred. For example, in 1952, due to severe atmospheric pollution from burning coal, 3,500 persons in London died within several days, and in terms of the number of fatalities, this was equivalent to one yet-to-occur worst case scenario of a nuclear power plant.

Up to now, the biggest nuclear power plant accident in the world was the nuclear power plant accident at Three Mile Island in the U.S. on 28 March 1979. As was mentioned in the fourth lecture, the influence on human health of the radioactivity released was very small.

From the above discussion one can draw the conclusion that during normal operation of a nuclear power the radioactive dosage on the environment is minute, and the frequency of accidental radioactive discharges which endanger life safety is also extraordinarily small. Actually, the impact of nuclear power plants on the environment is much less than coal-burning power plants.

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ENVIRONMENTAL QUALITY

ACID RAIN, OTHER FACTORS STUDIED IN DESTRUCTION OF PINE FORESTS

Beijing HUANJING KEXUE [JOURNAL OF ENVIRONMENTAL SCIENCES] in Chinese Vol 6, No 5, 30 Oct 85 pp 63-66

[Article by Yu Shuwen [0151 0647 2429] and Yu Ziwen [0205 1311 2429], Plant Physiology Institute of the Chinese Academy of Sciences, Liu Houtian [0491 0624 3944] and Shu Jianmin [5289 0313 3046], the Chinese Academy of Environmental Sciences, Ma Guangjing [7456 0342 7231], the Chinese Academy of Forestry Sciences, and Zhu Xiangyan [2612 4382 1484], Environmental Chemistry Institute of the Chinese Academy of Sciences]

[Text] In recent years, there are frequent reports of mass die-off of trees all over the country. In Sichuan alone, there are three serious cases: the Huashan pines (Pinus armandi) of Fengjie, the red pines (Pinus massoniana) of Choongqing and the firs (Abies delavayi) of Emei. In order to investigate the causes of death, the concerned state S&T Commission instructed the China Forestry Society to assemble a provisional investigation team. A team with members from the technical staff of the Chinese Academy of Sciences, Chinese Academy of Forestry Sciences, and Chinese Academy of Environmental Sciences was formed. Together with experts from the Sichuan Forestry Department, Sichuan Forestry Sciences Institute, Sichuan College of Agriculture, and the Forest Diseases and Pest Control Station of Yongchuan and Xichang, the team arrived at the locations in Sichuan in November 1984 for a 2-week investigation with emphasis on the forests of Fengjie and Chongqing.

1. The Die-offs of Fengjie's Huashan Pines

There are about 970,000 mu of Huashan pines in the Wan County area of Sichuan. Among them, 570,000 mu are damaged and 220,000 mu are dead. We chose to investigate the Maocaoba Forestry Center of Fengjie, the first to observe the die-off in this area. Within the Center, there are about 90,000 mu of pure Huashan pine forest that was artificially regenerated in 1958. Initially, the trees grew well. But now over 90 percent are dead and the surviving ones grow very poorly and are on the verge of death. The local authorities had investigated and discovered extensive disease and pest infestations. The disease was determined as premature dropping of needles caused by fungus. The pests were found to be long-horned beetles, pine beetles, and nematodes. Workers at the Center have tried standard procedures for the prevention and control of diseases and pests to no avail. Other measures such as tending,

rotation lumbering, clearing out sick and dead trees and adjusting canopy density are not effective either.

The premature dropping of needles occurred sporadically in the 1960's. In 1979, a large area was infested. The symptom started with the appearance of tiny yellow spots at the base of the newly sprouted needles of that year. They then grew gradually bigger, darkening until the needles turned yellowish-brown and then dropped. The clusters of fungi spores could be seen clearly from the withered needles on the ground. Signs of pests were abundant on the trunks of dead or dying trees. Tree bark peeled off upon touch. Nematodes were detected when the trunk samples of dead, sick, and seemingly normal trees were examined by microscope. The pest infestation is still going on in the woods and destruction is inevitable. No abnormality was found when the roots were examined.

The Maocaoba Forestry Center is located in a remote mountain region, yet, surprisingly, there are many pollution sources both inside and outside the Center--small-scale sulfur plants. These plants excavate and extract sulfur from local sulfur-rich ores. Our preliminary understanding is that there are sulfur plants operated by the seven townships in this region, including over 30 clay pits. In addition, there are some small family-run plants. These plants are operated with simple equipment and primitive technology. A large proportion of the sulfur in the ores is converted into sulfur dioxide in the production process and released into the atmosphere. Using an automatic sulfur dioxide analyzer, we carried out a two-hour continuous sampling around a small plant. The highest concentration of sulfur dioxide was 2.83 mg/m^3 about 500 meters from the plant and 0.90 mg/m^3 about 1,000 meters from the plant, both far exceeding the allowed concentration. The area within 1,000 meters of the plant is completely bare with no sign of vegetation. The leaves of vegetables grown around workers' residences nearby are densely covered with greyish-white necrotic spots, typical signs of acute sulfur dioxide damage. About 2-4 li downwind from the plant, there are over 10,000 mu of dead Huashan pine. Looking from a distance, it is a patch of dark-brown. This is where the die-offs first appeared among Maocaoba's 90,000 mus of pine. The needles of individual surviving pine tree are either reddish or yellowish with the tips dried or withered, a typical symptom of sulfur dioxide damage. Furthermore, white necrotic spots appear on the pointed tips and edges of arrow bamboo leaves.

There is no local acid rain information recorded. The investigation team measured the pH of the dew formed at the tip of the pine needles. About 1,500 meters from the plant, it is generally 3.5-4.0 with the lowest reading being 3.0. This dew contains the dissolved secretions of the needle and are distinctive from raindrops. Judging from the pH values, it can be concluded that the presence of seriously damaging acid rain and acid fog is highly likely.

II. The Die-offs of Chongqing's Red Pines

Currently, there are about 27,000 mu of forest at Nanshan, the scenic area on the sourthern bank of the Chang Jiang at the outskirts of Chongqing. It is predominantly artificially maintained red pine forest with small patches of

bamboo, dark pine (Pinus thunbergii) and camphor trees (Cinnamomum camphora). Since the 1960's, the red pines have not grown well in general and mass die-offs have occurred since 1982. At present, half of them have perished and the remainder face extinction. The local authorities had invited experts to investigate and it was found that the flora of the area was reduced from about 1,000 species to around 260. There is a serious ecological disturbance as evidenced by the damaged vegetation, soil erosion, loss of bird population and disappearances of animals and rampant infestation of diseases and pests. According to the record, there have been 15 episodes of pine moth outbreak during the 31 years since 1953, 2 in the 1950's, 4 in the 1960's, 6 in the 1970's and 3 within the 4 years into the 1980's. Not only has the frequency increased but the extent of damage is also growing. During the 1983 outbreak, the moth/tree ratio was 100 percent and the moth population density reached as high as several thousands. After repeated pine moth devastations, the trees are severely weakened and trunk-boring pests such as long-horned beetles, lesser pine beetles, pine beetles, and weevils flourish. A survey done a year ago showed that two-thirds of the forest was infested with black long-horned pine beetles with 44 percent of the trees dead or dying and merely 2 percent healthy. The hairy-forehead pine beetles also prefer the dead, dying or severely weakened trees. They are not found to damage the healthy ones and are rarely present in the moderately weakened. Besides the trunk-boring species, there are also nematodes, both saprophytic and parasitic, at the xylem. Nematodes in large numbers are found in 94 percent of the dead trees and 71 percent of the dying ones, as high as 437 nematodes per gram of wood having been observed. They are also present in 50 percent of the weakened and 7 percent of the healthy ones but in smaller numbers. It is known that black long-horned pine beetles and lesser pine beetles are the vehicles for the spread of nematodes, which is the cause of the wilting of pine trees. The connection between wilting and the die-offs of Nanshan's red pine is not yet established.

Throughout this investigation we notice that: the trunks of dead trees are covered with signs of pest infestation; the surviving trees grow poorly, pine trees about 30 years old generally having only 3-4 clusters of branches with their crowns about the size of that of a normal young 6- or 7-year-old tree; 2- to 3-year-old pine needles are non-existent and a large proportion of the needles of the young trees display the typical symptoms of sulfur dioxide damage with the symptoms more apparent on the windward side that is closer to and facing the built-up area; there is generally no sign of acute damage in areas far away or not facing direct wind but signs of chronic damage do exist, namely the lack of vitality and the premature dropping of needles. These signs of chronic damage can still be observed at the Nanjiao Park, which is farther away from the city.

The air pollution and acid rain of Chongqing have been systematically monitored. The average concentration of sulfur dioxide within the city is 0.45 mg/m^3 with the highest being 0.72 mg/m^3, 3-4 times the allowed amount on the average. This investigation team carried out a night-time, 7-hour continuous measurement. The average concentration is 0.21 mg/m^3 with the highest being 1.00 mg/m^3. There is a 3- to 4-year record on acid rain in this area. The pH is 4.4 in 1981, 4.2 in 1982, and 4.1 in 1983. The pH drops below 4.0 very frequently. In areas with pest infestations, the pH of the

soil is 3.9 with the lowest being 3.6. It is obvious that the pollution is very serious.

III. Analysis of the Causes of the Pine Forest Die-offs

Based on the information gathered by local technicians on their on-site investigations and on our own observations, there is no doubt that the mass die-offs of Huashan and red pine are caused by diseases and pests. But what triggers these rampages of disease and pest?

Diseases and pests exist in the forest and can attack or feed on the plants. But the plants possess a protective mechanism to keep them from becoming devastating. Both sides exist in a state of checked balance. Because the plants' defense mechanisms against diseases and pests and the latter's countermeasures to avoid or overcome the former's defense are not absolutely effective, no one side has the absolute advantage over the other. Therefore, they often co-exist in an ecological system. However, when the internal or external environments are altered, then the breakdown of the old ecological balance can trigger the outbreak of a certain disease or pest. Air pollution is one of such environmental factors.

In recent years, the exacerbation of disease and pest infestations in areas of air pollution have often been reported and there are some information on this aspect in the literature. It is estimated that the disease and pest infestations triggered by air pollution have inflicted greater economic loss to agriculture and forestry than the direct loss caused by air pollution's damages to plants. The air pollution of Chongqing is rather serious and the rural area of Fengjie has many localized pollution sources. The pollutant, sulfur dioxide, has caused acute and chronic damage to the pine trees as evidenced by the symptoms displayed on their needles. But this kind of direct damage is not sufficient to cause death over a large area. The direct causes of the death are diseases and pests. Air pollution and acid rain trigger the outbreak of diseases and pests. The reasons that air pollution help exacerbate certain disease and pest infestations are as follows:

1. The acute and chronic damages caused by air pollution weaken trees and hence provide "hot beds" for the invasion and flourishing of diseases and pests. The majority of trunk-boring pests preferentially attack the weakened or dying trees. Under the circumstances, the increase in pest population actually reflects the increase in the proportion of the weakened trees. The sites of damage caused by pests or air pollution can become windows that are vulnerable to infection.

2. Air pollution disturbs the original ecological balance. Among the pests, some are sensitive to the pollutant while others are resistant. The relationship between the two groups is one of interaction and counterbalance. Air pollution can weaken or even eliminate some pests and boost the others or even cause their numbers to explode.

3. Air pollution alters the physiological and biochemical processes of plants. A number of primary metabolites such as carbohydrates, organic acids, amino acids, proteins, and lipoids are disturbed in the presence of a

pollutant. These changes, though small, can have a significant impact on the feeding pattern and behavior of insects. For example, the Mexican bean beetles prefer the leaves contaminated with sulfur dioxide. After feeding on them, the beetles grow bigger and faster with strong reproductive ability. Secondary metabolites such as flavones, phenolics, steroids, and terpenes also strongly influence the growth and behavior of pests. Among them, terpene is a volatile substance secreted by pine trees and is a chemical signal to insects. The presence of sulfur dioxide in the air will activate the release of terpenes from pine trees, which consequently lures insects toward them.

4. Air pollution causes physical changes in plants. For example, the leaves damaged by sulfur dioxide change color to yellow, brown, dark brown, or black. And the host selection of some insects is strongly influenced by the color. Also, sulfur dioxide induces the dehydration of plant leaves and slight dehydration of leaves is a favorable condition for the growth and propagation of insects.

Through its interaction with plants, acid rain also has impacts on diseases and pests. In general, the impact of acid rain on plants is mostly indirect. Through acidification of soil, it alters the bioactive forms of the metallic elements in soil such as phosphorus, clacium, magnesium, and molybdenum, and hence degrades the nutritional condition for plants and results in reduced growth. The lowering of soil pH increases the solubilities of such elements as iron, manganese, and aluminum to the extent that their concentrations become toxic to the plants. The weakening of plants is another favorable condition for the outbreak of diseases and pests.

In addition to air pollution that causes the die-off of a forest by triggering disease and pest infestations, there are other possible causes. For example, the woods at both locations contain a single species and that usually means a weaker ecological system that is favorable for the spread of diseases and pests. Furthermore, the Maocaoba Forestry Center is located in a cold, high-mountain region with an elevation of 1,500-2,000 meters. There are reports that the damage of Huashan pines is dependent on the elevation. Serious damage occurs at higher altitudes. Hence the deaths are attributed to unfavorable location. There is also a theory that the deaths may have to do with a number of tremendous cold waves experienced in winter because of the climatic irregularity in recent years. It seems that these two factors are not without impact on the growth of Huashan pines. Nevertheless, there is not enough evidence to conclude that they are the main causes of the mass die-off of forests.

IV. Problems and Suggestions

1. At present, the rural industries are booming and making significant contributions to the modernization of China. But a by-product is the problem of air pollution being spread from urban to rural areas and progressing from individual pockets to cover whole areas. Many rural factories have severely polluted villages and small towns and this pollution is being fed back to cities in the form of agricultural products. Here, it also involves a basic question of how to develop industry: is it appropriate to develope certain industries in rural areas by a cluster of small, backward operations?

Generally speaking, rural areas do not have adequate tehcnological background. Running a primitive shop often is a waste of resources and causes serious pollution of three industrial wastes. Take Maocaoba as an example. Operating sulfur plants to fully utilize the local sulfur-containing ores is an important approach to advance the economy of this mountain region. But, at present, these small plants have caused severe problem for forestry productions by polluting the air due to their obsolete technological processes and their lack of facilities to treat the three industrial wastes. Although the plant operators may profit in hundreds of millions of yuans, the national forestry industry stands to lose hundreds of millions. Since the establishment of the forestry center in 1958, the state had invested a total of 3.6 million yuan up to 1984. Now, 90,000 mu of forest are dead with a loss of 12 million yuan worth of timber. This is only the financial balance sheet. As to the ecological effect, the damage is incalculable. And the impact is not limited to our generation. Future generations will suffer too. Weighing the pros and cons, it appears inappropriate for such industries as sulfur plants to be run in the rural areas by a cluster of small and primitive operations.

2. Reports of air pollution causing the death of large areas of forests have appeared in Scandinavia, central Europe, and North America. Now it has happened in China: the death of a forest is caused by rural air pollution at Maocaoba and by urban air pollution at Chongqing. Chongqing is one of China's cities having air pollution. The acid rain in its area is also serious. Within the city, trees lining the streets are gradually being eliminated by air pollution and only pistache trees survive. The red pines on the outskirts are the first to suffer damage due to their sensitivity to sulfur dioxide. If the pollution continues, other species will follow. Agriculture and forestry are but one aspect of the loss. The corrosion of machineries, buildings and equipments by acidic pollutants as well as the threat of human health deserve more attention. What is happening here can serve as a warning to other large cities.

3. There are several unique features in forestry production: besides economic, benefits, forest regeneration also has short- and long-term environmental impact; it has an especially long production cycle and is extremely susceptible to the influence of environmental factors including natural and man-made disasters. Therefore, the policies governing the forestry production units at all levels ought to be different from those of industry and agriculture. As far as the Maocaoba Forestry Center is concerned, 20 years of painstaking efforts are wasted. It faces the tremendous task of generating anew the whole forest. According to the decision of higher authorities, the budget for the center will be eliminated, effective September 1984. It has to seek its own financial resources. Thus, the Center faces the situation of "close-down, stop operation, merge, or switch." Through 20 years of investment by the state, the Center has just established itself with a team of specialists. Although it is in a very difficult situation at the moment, its employees and staff all express their willingness to hang on. The nearby Sanxia project will soon start and the works on the water and soil retention along the riverbanks should be kept at the same pace. Trees should be planted without any delay. The state should

give forestry centers like this one the kind of support usually given in emergencies.

4. Take on the comprehensive study of forest environmental protection. The above analysis of the causes of the death of forests is only the preliminary results of a short-term investigation. The connection between the forest die-offs at both locations and air pollution and acid rain is confirmed. But to what extent? How about the other environmental factors? To clarify these points requires systematic observations and studies. Whether from the practical or theoretical point of view, the correlation between the disease and pest infestation in plants and air pollution is a particularly important and significant subject. Yet this is basically an untouched area in China. The urgent tasks in front of us are to carry out further study on the causes of the die-offs in order to find effective countermeasures to save forests in other areas and to draw up forest regeneration plans. Such a study involves many disciplines including forestry, environmental sciences, plant protection, plant physiology and biochemistry, soil science, and meterology, and needs a multi-disciplinary approach. In the past, it was often done by engaging a single discipline to study only one aspect of the problem. As a result, the conclusions and countermeasures were rather limited in scope. These lessons should be well remembered.

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Aerodynamics

NUMERICAL PREDICTION OF SUPERSONIC BOUNDARY-LAYER TRANSITION

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 9-18

[English abstract of article by Zhang Guanghua [4545 0342 5478] and Yang Hui [2799 6540] of Qinghua University]

[Text] In this paper the turbulence model developed by Wilcox and Traci for predicting boundary-layer transition has been improved in some aspects. A series of numerical experiments have been performed on the improved model to predict the supersonic boundary-layer transition on a sharp cone with zero angle of attack. The computational results are compared with the wind-tunnel test data reported by van Driest and Boison. Satisfactory agreement between numerical and wind-tunnel experiments is obtained in many major aspects.

MOVEMENT OF HYDROMETEOR PARTICLE CLOUD IN BOW SHOCK LAYER

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 28-34

[English abstract of article by Zhao Guoying [6392 0948 5391] of the Institute of Mechanics, Chinese Academy of Sciences]

[Text] During reentry, high speed vehicles may encounter condensed phase H_2O in the form of ice particles or liquid droplets, which form so-called particle clouds. These particles must traverse the shocked air layer enveloping the reentering vehicle prior to impacting the surface. The interaction between the gas and the particles in the shock layer is usually investigated by calculating the trajectory of every particle in the gas flow field without consideration of the presence of other particles (this method is called one-way coupling). This paper presents a gas-(solid and liquid) particle two-fluid flow model, including the interaction (i.e., the mass, momentum and heat transfer) between the two phases (that is, a two-way coupling is taken into account), and the dissociation and ionization of the air and the dissociation of the steam (from the particle cloud). The model is solved by using the line method. The flow field of gas and the particle cloud is obtained, and the applicable range of one-way coupling is studied. Finally some interesting discussions are presented.

KERNEL FUNCTION METHOD FOR UNSTEADY TRANSONIC FLOW PAST LOW-FREQUENCY OSCILLATING BODIES OF REVOLUTION

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 45-54

[English abstract of article by Cheng Jianyu [4453 0256 1342] and Zhuang Lixian [8369 4409 6343] of the University of Science and Technology of China]

[Text] An approximate method is developed to calculate the unsteady surface pressure distributions and stability derivatives for elongated axisymmetric bodies of revolution undergoing harmonic pitching oscillations in transonic flow. The analysis is based on the time-linearized transonic small disturbance equation and the concept of local linearization. An integral equation is obtained and solved numerically with the panel method. Some results of the present method are compared with those of other theoretical methods and experiments.

NORMAL FORCE CHARACTERISTICS OF SHARP NOSED BODIES OF REVOLUTION AT HIGH ANGLES OF ATTACK IN SUBSONIC AND TRANSONIC FLOW

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 81-89

[English abstract of article by Tu Xing [1458 5281] and Wu Wenkang [2976 2429 1660] of Northwestern Polytechnic University]

[Text] The normal force characteristics of sharp nosed bodies of revolution were investigated experimentally at high angles of attack in a Mach number range from 0.35 to 1.20. The test results were analyzed. It was shown that both the Mach number and the Reynolds number strongly influence the normal force characteristics. The calculation methods based on crossflow theory had not taken into account the effects of viscosity and compressibility, so the actual phenomenon could not be represented.

The present research also investigated the effect of rolling orientation on the normal force characteristics experimentally. It was shown that the vortex pattern on the leeside surface has a considerable effect on the normal force coefficient. The difference of the normal force coefficient for different rolling orientations is approximately the same as the magnitude of the Mach number effect. For sharp nosed bodies of revolution the vortex pattern on the leeside surface cannot be predicted precisely. For the same model, at the same angle of attack, the vortex pattern is different with different rolling orientations. Therefore, we can predict that the aerodynamic characteristics of sharp nosed bodies of revolution at high angles of attack should not be unique, and they can vary within a certain range.

EXPERIMENTAL INVESTIGATION OF TURBULENT JET

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 90-97

[English abstract of article by Ke Liwen [2688 2621 2429] and Yan Xiqin [7051 0823 0530] of Beijing Institute of Aerodynamics]

[Text] The measurements of a turbulent jet have been made using a crossed hot-wire anemometer. The air jet issues from four nozzles with diameters of 3.91, 5.53, 8.74 and 12.36 mm respectively. The ambience is still air. The issuing velocity of the jet is from 16 m/s to 270 m/s. The measurements have been divided into four parts: (1) The longitudinal variations of the mean velocity and turbulence intensity on the jet axis; (2) The radial distribution of mean velocity, turbulence intensity and shear-stress in the fully developed region; (3) Third and fourth order moments; (4) Self-correlation coefficient and one-dimensional spectra of u_z on the jet axis.

9717
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Lasers

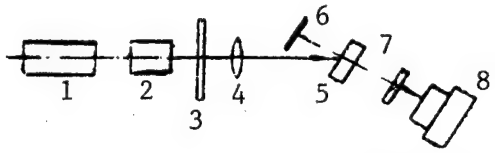
LASER OUTPUT PROPERTIES OF A NEW CHINESE MADE DYE OXAZINE (1)

Hefei ZHONGGUO KEXUE JISHU DAXUE XUEBAO [JOURNAL OF CHINA UNIVERSITY OF SCIENCE AND TECHNOLOGY] in Chinese Vol 15 No 3, Sep 85 pp 265-270

[Article by Ma Yurong [7456 3768 5554] and Tan Shici [6223 4258 1964] of Department of Physics, China University of Science and Technology, and Li Feng [2621 4539/7364] of Tianjin Institute of the Dyestuff Industry]

[Abstract] A high laser otput was obtained with a new type dye, oxazine (1), pumped by an electro-opto-Q-switching double frequency YAG laser. The bandwidth of the laser output is 6650 to 7070Å; the center wavelength is 6860Å. The output versus concentration curves were plotted. When the pumping power remained constant, the laser output was the highest at an optimal oxazine (1) concentration. Its output intensity and the laser conversion efficiency depend heavily on pumping intensity; i.e., the stronger the pumping intensity, the higher the laser output and the conversion efficiency.

An experimental setup of the YAG double frequency laser pump dye oxazine (1) is shown in the following:



Key:
1. YAG laser
2. Lithium niobate frequency multiplier
3. Light filter with total reflection at 1.06 micrometers and transmission at 0.53 micrometer
4. Focusing lens
5. Dye box
6. 6900Å total reflecting mirror
7. 6943Å semireflecting mirror
8. Receiver

Six other figures show an absorption property curve and a fluorescence property curve of oxazine (1) spectral property of laser output, laser pulse waveform of oxazine (1) and pumping light pulse waveform, the effect on laser conversion efficiency by different concentrations of methyl alcohol in oxazine (1), and the relationship between laser conversion efficiency and the pumping light intensity. One table lists data showing the relationships of output intensity, conversion efficiency, and concentration.

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10424/9365
CSO: 4009/29

VIBRATIONAL ENERGY TRANSFER STUDY OF DICHLOROMETHANE (CH_2Cl_2) BY LASER INDUCED FLUORESCENCE METHOD

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1261-1268

[English abstract of article by Gao Wenbin [7559 2429 2430] and Shen Yuqi [3088 3768 0366] of Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Hefei; and J. Häger and W. Krieger of Max-Planck-Institut für Quantenoptik, FRG]

[Text] In this work, the vibrational energy transfer of the organic molecule CH_2Cl_2 was studied with the laser induced fluorescence method for the first time. The activation and deactivation rate constants of modes ν_8 and ν_3/ν_9 of pure CH_2Cl_2, as well as the effect of rare gases on the deactivation processes for ν_3/ν_9, were obtained. The relative probabilities of energy transfer from the ν_3/ν_9 vibrational modes of CH_2Cl_2 to a translatable degree of freedom were calculated by means of SSH theory for the collision relaxation processes of the CH_2Cl_2-rare gas mixtures. A vibrational energy transfer channel in CH_2Cl_2 is also discussed.

Physics

CRITICAL PHENOMENA IN OPTICAL BISTABILITY AND CHAOTIC MOVEMENT

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1233-1240

[English abstract of article by Wang Pengye [3769 7720 2814], Zhang Hongjun [1728 3163 6874] and Dai Jianhua [2071 1696 5478] of the Institute of Physics, Chinese Academy of Sciences]

[Text] The critical phenomenon of bistability is discussed based on the relaxation equation of nonlinear systems with time-delayed feedback. We find that the critical slowing down at the edges of the bistable region is consistent with the divergence of the time duration of intermittency. The critical exponent is 1/2. We also find that, aside from the critical points at the bistable region edges, there are consistencies within the period-doubling bifurcation points and split bifurcation points at the cusp point (in the cust catastrophe model of bistability). The critical exponent is 1. The above-mentioned results possess universal properties. The computer experiments were conducted in a liquid crystal hybrid optical bistable device. The results are in agreement with the analyses.

STUDY OF TRANSIENT OPTICAL BISTABILITY OF QUASI-RESONANT-ABSORPTIVE DYE MEDIUM

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1241-1248

[English abstract of article by He Guangsheng [6378 0342 3932], Zhou Fuxin [0719 4395 2450] and Liu Songhao [0491 7313 6275] of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] Using an intense pulsed laser beam of 5320 Å to excite the BDN dye solution inside the F-P interferometer, we have found the transient and intrinsic optical bistability effect. The various possible mechanisms for inducing the refractive-index change of the sample medium and their relative contributions have been estimated. Also, it is confirmed that during the input laser pulse the refractive-index variation increases with time approximately in the form of a semi-cubic parabola, and the main mechanism causing this variation is the opto-thermal effect of the sample medium.

INFRARED DIVERGENCE THEORY OF ULTRASONIC ABSORPTION IN GLASSES

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1269-1279

[English abstract of article by Fan Xiqing [5400 1585 1987], Wang Guoliang [3769 0948 2856] and Dai Peiying [2071 1014 5391], et al., of the Department of Physics, Zhengzhou University; and Liu Fusui [0491 4395 4840] of the Department of Physics, Beijing University]

[Text] Starting from Ngai's unified theory of low-frequency fluctuation, dissipation and relaxation processes, we studied the ultrasonic absorption in the thermal activation process in glasses. The theory involves only a single relaxation time and differs from the theory of distributed relaxation times. Nonetheless, it can explain the experimental characteristics of ultrasonic absorption in glasses and the universality of these characteristics, independent of kinds of materials, which could not be interpreted by the previous theory on the distribution of relaxation times.

AN ASED-MO STUDY OF THE MICRO MECHANISM OF ACTIVATION OF CO ADSORBED ON Ni(100) AND POISONING BY THE SUBMONOLAYER S ATOM

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1291-1298

[English abstract of article by Cao Peilin [2580 1014 2651] and Shi Danhua [2457 0030 5478] of the Department of Physics, Zhejiang University, Hangzhou]

[Text] Using an atom superposition and electron delocalization molecular orbital (ASED-MO) theory, the micro-mechanism of activation of CO adsorbed on Ni(100) and of poisoning by the submonolayer S atom is studied. CO is found to bond to the top site more strongly than on the fourfold site. When CO is adsorbed on the top site, it will get 0.72e on its antibonding 2π orbital, and its dissociation energy will reduce from 11.1 eV for a free CO molecule to 2.15 eV. If CO is adsorbed on the fourfold site, the electrons on its 2π orbital will be 1.22e and dissociation energy 1.85 eV. It seems likely that CO adsorbed on the fourfold site is more active. Our binding energy calculations have verified that one S atom adsorbed on Ni(100) will inhibit the four nearest top sites and the four nearest fourfold sites from adsorbing the CO molecule, but will not significantly affect farther sites. These results support the idea that the dominant effect of adsorbed S atoms is the "structural effect." The "blockage" effect by the adsorbed S atom, i.e., the reduction of the active sites, and some other factors result in the poisoning of Ni surfaces by the submonolayer S atom.

INVESTIGATION OF CO AND NO CHEMISORPTION ON VIII GROUP TRANSITION METAL SURFACE BY X_α-DV METHOD (I). ELECTRONIC STRUCTURE OF CHEMISORPTION OF CO ON Rh(111) SURFACE

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1299-1305

[English abstract of article by Chen Yunqi [7115 5366 3875] and Zheng Dejuan [6774 1795 1227] of the Institute of Physics, Chinese Academy of Sciences; and Cao Peilin [2580 1014 2651] and Wu Yue [0702 6885] of the Department of Physics, Zhejiang University, Hangzhou]

[Text] In this paper, the electronic structure of chemisorption of CO on a Rh(111) surface ($\theta \leq 1/3$) has been calculated by the self-consistent Hartree-Fock-Slater molecular cluster method. The variation of the energy levels and total energy with respect to the vertical distance of the CO molecule above this surface is obtained. The optimized bond distance determined from the total energy curve is 1.85 Å, which is quite close to the experimental results of 1.95 ± 0.1 Å. The binding energy is 0.98 eV, which is smaller than the experimental adsorption energy of 1.3 eV. The total density of states with the above bond distance is calculated, and it is in good agreement with the UPS results which consider the final state and relaxation effect. The bonding and antibonding characteristics for the CO valence level have also been studied by analysis of the variations of the molecular eigenvalues when the CO molecule approaches the surface. The charge transfer for CO chemisorption on the transition metal Rh is investigated through Milliken population analysis and the analysis of coefficients of the cluster wavefunction, which is expanded using the CO molecular wavefunction. This charge transfer causes the activation of absorbed CO molecules.

INVESTIGATION OF CO AND NO CHEMISORPTION ON VIII GROUP TRANSITION METAL SURFACE BY X_α-DV METHOD (II). CHEMISORPTION OF NO ON Pd(111) SURFACE

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1306-1314

[English abstract of article by Wu Yue [0702 6885] and Cao Peilin [2580 1014 2651] of the Department of Physics, Zhejiang University, Hangzhou; and Chen Yunqi [7115 5366 3875] and Zheng Dejuan [6774 1795 1227] of the Institute of Physics, Chinese Academy of Sciences]

[Text] The chemisorption of NO on Pd(111) surface is calculated using the X_α-DV method. Its electronic structure, including the spectrum of the ground state valence levels, density of states and the charge transfer between the adsorbate and substrate, is obtained. The interaction between adsorbed NO molecules is included in the calculations. The results of DOS are in good agreement with UPS, supporting the LEED structural analysis, and the adsorption height is determined to be 1.27 Å. The theoretical results verify that the interaction between NO molecules is important in the chemisorption of NO on Pd surfaces. The activation of adsorbed NO on Pd(111) is discussed. It is evident from the results that the charge transfer between adsorbed NO and the substrate is similar to CO adsorption on transition metals. Finally, it was found that the adsorption of NO does not significantly affect the valence band of Pd.

EXPERIMENTAL DETERMINATION OF THE STEREOCHEMICAL STRUCTURE OF H_3^+

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1315-1321

[English abstract of article by Miao Jingwei [4924 4552 1218] and Yang Baifang [2799 4102 2450], et al., of the Institute of Nuclear Science and Technology, Sichuan University, Chengdu]

[Text] The measurement of the stereochemical structure of the H_3^+ molecular ion is reported. This measurement makes use of the Coulomb explosion of a fast molecular ion. It is shown that the structure is equilaterally triangular in shape. The mean value of the most probable interproton separations is found to be 0.98 ± 0.03 Å. Also described is a set of high resolution experimental arrangements.

PRESSURE EFFECT ON THE STABILITY AND PHASE TRANSFORMATION OF THE ε-PHASE IN SPLAT QUENCHING Fe-C-Sb ALLOY

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1322-1326

[English abstract of article by Qin Zhicheng [4440 1807 2052], Chen Xichen [7115 3556 3819] and He Shouan [0149 1108 1344], et al., of the Institute of Physics, Chinese Academy of Sciences]

[Text] The pressure effect on the phase transformation process of the ε-phase of a splat quenching Fe-C-Sb alloy has been investigated using X-ray powder photography. The experimental results show that high pressure will not only increase the stability of the ε-phase remarkably, but will also change its phase transformation process. At 4.7 GPa, as the stability temperature of the ε-phase increases to 450°C, a new metastable phase of orthorhombic structure, absent at normal pressure, will appear. By raising the annealing temperature to 560°C, the orthorhombic metastable phase begins to transform into Fe_3C, which will decompose into carbon (graphite) and γ-Fe when the annealing temperature is further increased to 800°C. At this time, the alloy is composed of C (graphite), γ-Fe, Sb and another unknown phase.

THE CRYSTALLIZATION PROCESS OF METGLASS $(Fe_{0.1}Co_{0.55}Ni_{0.35})_{78}Si_8B_{14}$ AND THE EFFECT OF HIGH PRESSURE (II). THE CRYSTALLIZATION TEMPERATURE AND THE CRYSTALLIZATION ACTIVATION ENERGY

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1327-1335

[English abstract of article by Shen Zhongyi [3088 0022 3015], Zhang Yun [1728 0061] and He Shouan [0149 1108 1344], et al., of the Institute of Physics, Chinese Academy of Sciences; and Chu Shaoyan [0328 1421 1484] of Nanchang Aviation Institute]

[Text] In this paper the pressure dependence of the crystallization temperature T_x and the crystallization activation energy ΔE_x of metglass $(Fe_{0.1}Co_{0.55}Ni_{0.35})_{78}Si_8B_{14}$ are studied by measuring the electrical resistivity in-situ under pressure of up to 3 GPas. It is found that application of high pressure does not raise the T_x linearly, or even monotonically, as is usually described in the literature about pressure dependence of T_x in metglasses, but instead shows some local detours on the T_x vs P curve in a generally rising tendency. ΔE_x shows some behavior that is analogous to that of T_x as the pressure rises.

An analytical discussion indicates that pressure promotes the nucleation process and restrains the diffusional growing of the crystallized nuclei on heating the metglass. As a combined result of the mutually contrasting effects of pressure on nucleation activation energy and diffusion activation energy, the above-mentioned non-monotonic rising behavior of ΔE_x and T_x of the metglass studied is produced. In addition to ΔE_x, pressure may also markedly affect the preexponential factor and produce a considerable change of the crystallization temperature.

STUDIES OF THE STRUCTURE OF AMORPHOUS MoS_3 AS CATHODE MATERIALS IN LITHIUM BATTERIES

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1336-1341

[English abstract of article by Guo Changlin [6753 1603 7207] and Lu Changwei [7120 2490 0251], et al., of Shanghai Institute of Ceramics, Chinese Academy of Sciences; and Yu Zhizhong [0205 1807 0022] of Shanghai Institute of Testing Technology]

[Text] The structure of amorphous MoS_3 as the cathode material in lithium batteries was studied using the X-ray diffraction method and X-ray photoelectron spectroscopy. The results reveal that the structure of amorphous MoS_3 is built by homogeneously randomly stacking the MoS_2 basic unit S-Mo-S sandwich layers and the amorphous sulphus chains S_n.

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Polymers and Polymerization

STUDIES ON THE POLYMERIZATION OF BUTADIENE IN THE PRESENCE OF IRON CATALYST

Beijing GAOFENZI TONGKUN [POLYMER COMMUNICATIONS] in Chinese No 4, Aug 85 pp 258-262, 257

[Article by Liu Gouzhi [0491 0948 2535] and Wang Fengjiang [3769 7364 3068] of the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Abstract] It was found that the addition of compounds containing one nitrogen atom, such as pyridine, does not raise the catalitic activity in the polymerization of butadiene for the system of $FeCl_3$-$(i\text{-}C_4H_9)_3Al$, and that the compounds containing two nitrogen atoms can increase the activity in the following order: 1, 10-phenanthroline 2, 2'-dipyridyl>>ethylenediamine or tetramethyl ethylenediamine. The polymerization of butadiene in the presence of $FeCl_3$-$(i\text{-}C_4H_9)_3$ Al-phenanthroline have been studied in more detail. A possible mechanism is proposed. (Paper received 7 May 1983)

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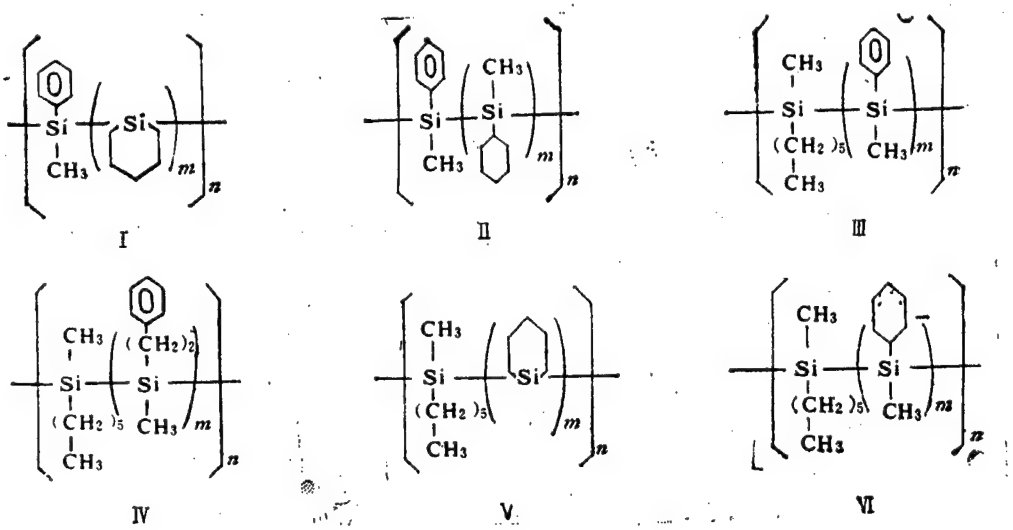
CSO: 4009/1027

SYNTHESES AND PROPERTIES OF SOME ORGANOSILANE POLYMERS

Beijing GAOFENZI TONGKUN [POLYMER COMMUNICATIONS] in Chinese No 4, Aug 85 pp 274-281

[Article by Zhang Xinghua [1728 5281 5478] of the Institute of Chemistry, Chinese Academy of Sciences, Beijing, and Robert West, Department of Chemistry, University of Wisconsin, Madison, Wisconsin]

[Abstract] Some organosilane polymers [see figure] with high molecular weights have been synthesized by cocondensation of organosilicon dihalide monomers with sodium metal in toluene. These polymers are readily soluble in common solvents and can be molded, casted into films or drawn into fibers. Upon exposure of the solid polymers to ultraviolet light the polymers tend leads to produce degradation or crosslinking. (Paper received 26 May 1983)



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Solar Energy

DEVELOPMENT OF ALL-GLASS EVACUATED TUBULAR COLLECTORS WITH BLACK CHROMIUM SELECTIVE COATINGS AND V-SHAPED SPECULAR REFLECTORS

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 341-346

[English abstract of article by Li Minghua [2621 2494 5478], Shi Xuejun [2457 7185 0689] and Wu Shuzhen [0702 4790 6297] of Shanghai Institute of Ceramics, Chinese Academy of Sciences]

[Text] In this paper the construction and performance of an all-glass evacuated tubular collector are introduced. The collector panel is composed of thermal collection vacuum tubes, manifold, frame and V-shaped specular reflectors. An evaporated black chromium selective film is coated on the outside of the inner absorber element. It is shown that, as a result of optimizing geometric parameters and the design of the V-shaped mirror reflector, the collector performs well in solar thermal conversion.

With the improvements if the manufacture of the manifold and fixation of the thermal collection tube, the collector possesses such excellent advantages as lower cost and ease in maintenance. These collectors are potentially applicable to solar industrial processing heat.

THE NATURE AND APPLICATIONS OF COBALT OXIDE COATING

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 347-352

[English abstract of article by Wang Guohua [3769 0948 5478] and Yuan Jinshe [5373 6651 4357] of Xinjiang Solar Energy Research Institute]

[Text] A new technique of spray pyrolysis is reported which produces cobalt oxide coating on aluminum plate. The surface microstructure of the coating is studied by electron microscope, and structural and optical properties of the coating are analyzed in detail. Test studies indicate that this coating has good adhesion to the substrates and is stable up to 400-600°C. The cobalt oxide selective surface has high absorption over the spectral range of the solar spectrum combined with low thermal losses due to reradiation at longer wavelengths. The α_s ε_n value is usually equal to 3-4.

PHOSPHORUS (P) DOPING EFFECTS ON THE ABSORPTION COEFFICIENT AND DENSITY OF GAP STATES OF a-Si:H

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 353-358

[English abstract of article by Wu Zongyen [0702 1350 8746] and Shen Yuehua [3088 2588 5478] of Shanghai Institute of Ceramics, Chinese Academy of Sciences]

[Text] The absorption coefficient of a-Si:H maps out the distribution of density of states above the valence band; the parameter γ from steady photoconductivity measurements may give information on the exponential conduction band tail. This paper describes P doping effects on a-Si:H gap states by means of these two parameters. Light doping raises only the density of deep states in the gap, while heavy doping increases the width of the valence band tail as well. However, doping has no obvious effect on the conduction band tail. Therefore, the decrease of the optical gap with doping is due only to the variation of the valence band tail.

EXPERIMENTAL INVESTIGATION OF HEAT LOSS CHARACTERISTICS OF AN EVACUATED TUBE COLLECTOR

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 372-376

[English abstract of article by Zheng Zhenhong [6774 2182 1347] and Huang Zhicheng [7806 1807 2052], et al., of Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences]

[Text] Heat loss from an evacuated tube collector and results of its experimental investigation are presented in this paper. The variation of heat loss rate with the vacuum degree, the effect of the vacuum degree on the heat loss, and the variation of the overall heat loss coefficient with the temperature difference are found. Heat loss from the vacuum tube can be reduced when the vacuum gap is filled with some kind of low thermal conductivity gas with the range of 1-10 torr.

EVAPORATED SiO COATING AND SERIES RESISTANCE FOR SILICON MIS/IL SOLAR CELLS

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 377-382

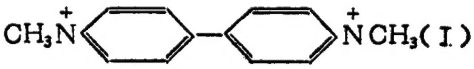
[English abstract of article by Zhang Xiumiao [1728 4423 8693] of the Department of Physics, Hangzhou University]

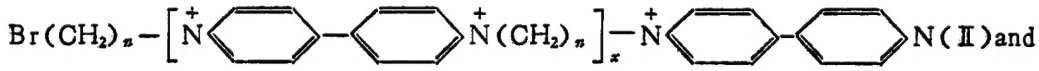
[Text] In this paper the series resistance for silicon MIS/IL solar cells related to the thickness of the evaporated SiO coating, the fixed positive charge density in the coating and the interface state density is indicated. The results show that in the case of the minimum thickness of the SiO coating required by antireflection property in order to decrease the series resistance to an acceptable level, it is important to increase the fixed positive charge density in the coating and to decrease the interface state density technologically.

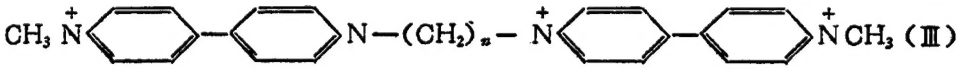
INVESTIGATION OF SEVERAL VIOLOGENS AS ELECTRON RELAY BY ELECTROCHEMICAL METHODS

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 383-391

[English abstract of article by Tang Huanyi [3282 3562 3015], Sun Mingshan [1327 2494 1472] and Wang Wenquan [3769 2429 0356], et al., of Dalian Institute of Chemical Physics, Chinese Academy of Sciences]

[Text] Three types of viologens,  (I)

 (II) and

 (III)

were studied comparatively. Their redox characteristics and reversibility in redox were investigated by the multicyclic potential sweeping technique, and the formation as well as the change of the reduced viologens produced during controlled potential electrolysis was followed by absorption spectra in situ. The behavior of photoelectrochemical cells containing different viologens was also examined. (I) was found to possess a more negative redox potential and a greater ability for electron transfer, but was less stable with oxygen. The absorption spectra of the reduced state V^+ of (II) and (III) were shown to be violet shifted when compared with those of MV^+. A serious problem in reversibility of the viologens was confirmed to be due to the formation of V^0 and their aggregation. In order to improve the stability of the catalyst system for H_2-photogeneration from water, it was proposed that the viologen and photosensitizer used as catalyst components should possess the potential order $E_{(H_2O/H_2)} > E_{(V^{2+}/V^+)} > E_{(PS^+/PS*)} > E_{(V^+/V^0)}$, and the reaction condition should be adjusted in such a way that the evolution of hydrogen would match the formation of V^+ in velocity.

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